BIOLOGICAL ASSESSMENT AND MANAGEMENT PLAN

MID-COLUMBIA RIVER HATCHERY PROGRAM

National Marine Fisheries Service
U. S. Fish and Wildlife Service
Washington Department of Fish and Wildlife
Confederated Tribes of the Yakama Indian Nation
Confederated Tribes of the Colville Indian Reservation
Confederated Tribes of the Umatilla Indian Reservation
Chelan County Public Utility District
Douglas County Public Utility District

April 1998

NOTE

Over a two-year period, fishery co-managers[1] and Chelan, Douglas, and Grant Public Utility Districts (collectively called the Mid-Columbia PUDs) developed this biological assessment and hatchery management plan for anadromous salmonids in the Columbia River usptream of the Yakima River confluence. This plan is support for an Anadromous Fish Agreement and Habitat Conservation Plan for anadromous salmonids being negotiated by the Mid-Columbia PUDs and the co-managers. The plan's goals are to (1) contribute to the recovery of species considered "at-risk" of extinction, and (2) partially compensate for unavoidable losses at the four[2] hydroelectric projects operated by the Mid-Columbia PUDs.

As of this date, Chelan and Douglas PUDs have completed negotiations with the co-managing agencies and tribes. Grant PUD has not completed negotiations. Many aspects of production, management, and evaluation of hatchery fish outlined in this plan are based on the participation of Grant PUD. The reader should be advised that full implementation of this program will not be done until a settlement agreement with Grant PUD is completed. Regardless, Chelan and Douglas PUDs' commitments in the plan can still be met even if a settlement with Grant PUD is delayed or cannot be negotiated.

Bob Bugert, Facilitator
Mid-Columbia Hatchery Work Group[3]
April 1998

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1 *The fishery comanagers include National Marine Fisheries Service, U. S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, the Confederated Tribes of the Colville Indian Reservation, the Confederated Tribes of the Yakama Indian Nation, and the Confederated Tribes of the Umatilla Indian Reservation.*

2 *Priest Rapids and Wanapum dams are considered by FERC to be separate developments of a single Priest Rapids hydroelectric project.*

3 *Copies of this plan can be obtained from Chelan County Public Utility District, P.O. Box 1231, Wenatchee, WA 98807-1231.*

BIOLOGICAL ASSESSMENT AND MANAGEMENT PLAN: MID-COLUMBIA RIVER HATCHERY PROGRAM

EXECUTIVE SUMMARY

This document is a consensus plan by fish co-managers for development, operation, and evaluation of anadromous salmonid hatcheries in the Columbia River upstream of the Yakima River confluence. The co-managers include National Marine Fisheries Service (NMFS), U. S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Yakama Indian Nation, Colville Confederated Tribes, the Confederated Umatilla Tribes, and Chelan, Douglas, and Grant Public Utility Districts (PUDs). This *Mid-Columbia Hatchery Program* is part of an application for a 50-year multi-species Habitat Conservation Plan (HCP) and relicensing agreement for the PUDs. This plan has two objectives: (1) To help recover natural populations throughout the Mid-Columbia Region so that they can be self-sustaining and harvestable, while maintaining their genetic and ecologic integrity; and (2) To compensate for a 7% mortality rate at each of the five PUD-owned mid-Columbia River mainstem dams (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) in a manner that is consistent with the first objective. Species included in this plan include chinook salmon, steelhead, sockeye salmon, and coho salmon. When the HCP is implemented, this plan will supersede all existing anadromous hatchery plans in the Mid-Columbia Region.

The two objectives in this plan were developed to be compatible with each other, and with NMFS policy for artificial propagation under the Endangered Species Act. The first objective (recover populations that are at risk of extinction) takes precedence, and will guide the strategies used in the initial years of the hatchery program. Once it appears that populations have recovered, and if it can be done in a manner that will not jeopardize them, hatchery production of these populations will increase to meet the second objective (compensation for hydropower-related mortalities). In general, the first objective uses a more conservative approach to artificial propagation than the second objective: fewer fish are propagated and stronger measures to protect natural fish are used. The co-managers designed the recovery strategies based on continued use of the existing hatcheries in the Mid-Columbia Region; they identified how to modify them where necessary, and recommended new facilities in the region to meet program needs.

In the initial stages of developing this plan, the co-managers assessed the probability of extinction for each species in the short term (10 years) and long term (50 years), given existing conditions. Using available ecologic, genetic, and demographic data, they determined that the risk of extinction was low for summer and fall chinook salmon and for sockeye salmon, but high for spring chinook salmon and steelhead (coho salmon are extinct in the region; the means to address this is described below). The first objective (population recovery) will be employed for these high risk species. Artificial propagation of the low risk species may proceed toward the second objective (compensation for mortalities). The co-managers then used these data to determine how to delineate "populations" within each species. For most species, the data indicated population divisions that generally coincided with geographic divisions. Although there are a few exceptions, most populations aggregate at the watershed level (i.e., the Wenatchee, Entiat, Methow, and Okanogan rivers). However, the data for spring chinook salmon were not conclusive, causing deliberation on the proper level of population separation and gene flow between the nominal populations.

Summer and fall chinook salmon At this time, these fish have a low risk of extinction in the Mid-Columbia Region. There, they predominately have an "ocean-type" life-history, which has among many traits, a tendency to migrate to the ocean as subyearlings (less than a year after they hatch). Currently, more summer and fall chinook salmon are artificially propagated in the region than any other species. Most hatcheries rear them to a yearling stage because they survive better at that age than subyearlings. Current hatchery production is: Wenatchee River, 864,000 yearlings; Methow River, 400,000 yearlings; Okanogan River, 576,000 yearlings; Columbia River at Wells Fish Hatchery (FH), 320,000 yearlings and 484,000 subyearlings; Rocky Reach FH 200,000 yearlings and 1,620,000 subyearlings; and Priest Rapids FH, 5,000,000 subyearlings (2,360,000 yearlings and 7,104,000 subyearlings total).

Since yearling chinook salmon released from hatcheries survive at much higher rates than subyearlings (up to 15 times higher), fewer fish need to be propagated as yearlings to meet the compensation levels required under the second objective. In the short-term, this strategy appears to have fewer ecologic impacts to natural fish (although some indicators are inconclusive). However, the Hatchery Work Group recognized that this strategy, in combination with relatively high numbers of naturally spawning hatchery fish, may have deleterious long-term genetic effects to natural fish. This may be impossible to detect in a timely manner. Given these constraints, the chosen strategy is to continue to propagate yearlings to compensate for dam mortalities; evaluate the genetic, ecologic, and demographic characteristics of the natural populations throughout the hatchery program; and recognize the risk that potential impacts may not be detected in sufficient time to correct them. Additional production to compensate for hydropower losses are 750,000 yearlings on Wenatchee River, 150,000 yearlings on Entiat River, 150,000 yearlings on Chelan River, 120,000 yearlings on Methow River, 300,000 yearlings near Chief Joseph Dam, and 1,000,000 subyearlings at Priest Rapids FH (1,470,000 yearlings and 1,000,000 subyearlings total). Means to collect local broodstocks on the Methow and Okanogan river will be studied.

Spring chinook salmon The co-managers concluded that many populations are at high risk of extinction, and artificial propagation was essential for their recovery. However, there was substantive debate on how to categorize and propagate the populations. Critical uncertainties were: (1) the level of population structure of mid-Columbia spring chinook salmon, (2) which strategies posed the least risk to the populations while having the highest likelihood of recovering them, and (3) whether these recovery measures were logistically feasible. The co-managers investigated several alternatives that could be used in the recovery process, while promoting within- and among-population genetic variability for the nominal populations. Some alternatives either presented an increased risk to the sustainability of the populations, or have low feasibility in implementation. As a result, the most appropriate plan included a limited use of many strategies to spread the overall risk to the populations and to test the effectiveness of each strategy. "Spreading the risk" includes the use of more than one artificial propagation strategy, collecting broodstock at more than one life stage, predetermined means to manage stray fish, variable levels of population separation, and designation of "reference" populations that will not be artificially propagated. All strategies will be monitored to allow comparison of the effectiveness of each alternative and subsequently, adaptive management of the program.

Five nominal populations will be managed in the Wenatchee Watershed (Leavenworth, Chiwawa, Nason, White, and Little Wenatchee). The preferred strategy for the Leavenworth Population is to retain the current production objective (1,625,000 yearling smolts), yet modify the program to assist in natural fish recovery. This includes further integration with natural production, outplanting into unseeded habitats within the Wenatchee Watershed, and discontinued imports of non-native broodstock. The preferred strategy for the Chiwawa Population is to reduce the production objective from 672,000 to 300,000 yearling smolts, which will more closely match the natural productivity of that stream. The Nason Creek and White River populations will be captively reared for two salmon generations (8 -10 years) to quickly increase their abundance, and then used to supplement those streams. The Little Wenatchee Population will not be artificially propagated at this time, to serve as a reference stream to compare recovery rates with those populations that are artificially propagated. Concurrently, a rigorous evaluation will be made of the reproductive success of hatchery and natural salmon in the natural environment in the Wenatchee Watershed.

The current hatchery production objective for the Entiat Population is to release 400,000 yearling and 400,000 subyearling smolts into lower Entiat River. This program has been based on use of both native and non-native populations. There is some evidence however that, because of several factors, these fish may be reproductively isolated from the potentially native natural spawners in that watershed. Given this uncertainty, the preferred strategy is to maintain the current program until the relation of Entiat FH fish and natural fish are determined. If the two groups appear to be reproductively integrated, the program will be modified to release up to 600,000 yearling smolts into lower Entiat River and outplant 200,000 yearling smolts in upper Entiat River. If the two groups are reproductively isolated, strategies may be developed to recover and conserve the natural population using methods other than artificial propagation. This population would then serve as a reference, similar to the Little Wenatchee Population.

The hatchery strategy for the Methow Population was developed after considering their historic and current population dynamics and genetic structure within the watershed. The preferred strategy is to continue the supplementation program at Methow FH (738,000 yearlings), based upon common native broodstock collected at Wells Dam, and to modify Winthrop FH into a supplementation program, similar to Methow FH. This will entail elimination of non-native fish from Winthrop FH, and further integration of hatchery and natural fish. Eventually, both hatcheries will work as a combined program. Winthrop FH will reduce production from 800,000 to 600,000 yearling smolts. Fish from the Twisp River will be captively reared as an adjunct to the supplementation program.

<u>Steelhead</u> At this time, steelhead are at high risk of extinction, and artificial propagation is essential for their recovery. The current program for steelhead in the Mid-Columbia Region is based predominantly on a common broodstock collected at Wells Dam. Yearling progenies are reared at Wells, Turtle Rock, Chelan, and Eastbank FHs and scatter planted at several locations in the Wenatchee, Entiat, Methow, and Okanogan Rivers. This program will be modified to encourage a higher level of adaptation to these streams and reduce gene flow among watersheds.

The preferred strategy for Wenatchee River is to collect broodstock on that river for propagation and release there only; program size will remain at 360,000 yearlings. The preferred strategy for Entiat River is to continue use of Wells broodstock in the short term (program size is 40,000 yearlings), while simultaneously investigating the feasibility of either (1) collecting a local broodstock on that stream for supplementing that population or (2) using the Entiat population as a reference, to compare its viability with artificially propagated steelhead. If the first option is pursued, an evaluation of “scatter-plant” versus acclimated releases will be done. The preferred strategy for the near-term for the Methow River is to continue broodstock collection at Wells Dam, and to investigate the means to collect local broodstock on the Methow River for the long term (production objectives are 380,000 yearlings reared at Wells FH and 100,000 yearlings reared at Winthrop FH). The preferred strategy for the Okanogan River is to continue collections at Wells Dam while investigating means to develop a local population for broodstock (production objectives remain at 100,000 yearlings, reared at Wells FH).

Sockeye salmon There are two populations of sockeye salmon in the Mid-Columbia Region, from the Wenatchee and Okanogan rivers. Both currently have low risk of extinction. The current production objectives are 200,000 yearlings from Wenatchee River, propagated at Eastbank FH, and 200,000 subyearlings from Okanogan River, propagated at Cassimer Bar FH. The programs acclimate fish with net pens on lakes Wenatchee and Osoyoos, respectively. Production will increase to approximately 725,000 fish of various ages on Wenatchee River and 2,200,000 fish of various ages on Okanogan River and the mainstem Columbia River upstream of Wells Dam. The number of each population to be produced, and the means to propagate them will depend on several factors outside the scope of this plan. Similar to that for summer and fall chinook salmon, hatchery production of sockeye salmon will be monitored to assess its effects on natural salmon, and to help guide the means to increase the production.

Coho salmon At this time, coho salmon are extinct in the Mid-Columbia Region, and this plan will artificially propagate them only once natural populations are re-established. Coho salmon are being reintroduced to the region through processes outside the scope of this plan.

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ACRONYMS USED IN TEXT

BPA	Bonneville Power Administration
CCT	Colville Confederated Tribes
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
cfs	cubic feet per second
CRFMP	Columbia River Fish Management Plan
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FH	Fish Hatchery
fpp	fish per pound
GCFMP	Grand Coulee Fish Management Project
GCMU	Genetic Conservation Management Unit
GDU	Genetic Diversity Unit
gpm	gallons per minute
IDFG	Idaho Department of Fish and Game
IHOT	Integrated Hatchery Operations Team
JARPA	Joint Aquatic Resource Permit Application
JFP	Joint Fishery Parties
LSRCP	Lower Snake River Fish and Wildlife Compensation Plan
MSP	Methow Basin Spring Chinook Salmon Supplementation Program
MCMCP	Mid-Columbia Mainstem Conservation Plan
NMFS	National Marine Fisheries Service
NNI	No net impact
NPPC	Northwest Power Planning Council
ODFW	Oregon Department of Fish and Wildlife
PAC	Production Advisory Committee
PNFHPC	Pacific Northwest Fish Health Protection Committee
PUD	Public Utility District
RASP	Regional Assessment of Supplementation Project
RIHC	Rock Island Fish Hatchery Complex
RK	River kilometer
SASSI	Salmon and Steelhead Stock Inventory
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
YIN	Yakama Indian Nation
WDFW	Washington Department of Fish and Wildlife
WSP	the WDFW Wild Salmonid Policy

BIOLOGICAL ASSESSMENT AND MANAGEMENT PLAN: MID-COLUMBIA RIVER HATCHERY PROGRAM

SECTION 1: PROGRAM OVERVIEW

1.1: Goal Statement

One biological goal of the Mid-Columbia Mainstem Conservation Plan (MCMCP)[4] is to achieve No Net Impact (NNI)[5] to the productivity[6] of anadromous salmonids originating in the Mid-Columbia Region[7] due to the operation of the mid-Columbia River hydropower dams[8] (Figure 1). This goal must be achieved in a manner that is compatible with self-sustaining natural populations. The primary means to achieve NNI is to ensure a high survival rate of fish passing through the five reservoirs and project structures. However, some impacts will be unavoidable or extremely difficult to mitigate. Measures taken by the Mid-Columbia PUDs to improve natural production of anadromous fish in the region will compensate for mortality in project and reservoir passage. Two strategies will be used: (1) habitat protection and restoration, and (2) hatchery production of affected species in the mainstem mid-Columbia River (Figures 2 and 3), and its four major tributaries: the Wenatchee (Figure 4), Entiat (Figure 5), Methow (Figure 6), and Okanogan watersheds (Figure 7).

This document outlines the approach developed for hatchery production by a "Hatchery Work Group" (HWG) designated by the MCMCP participants[9]. The Mid-Columbia Hatchery Program has two major objectives, that are ranked in priority:

(1) To contribute to the rebuilding and recovery of naturally spawning populations throughout the Mid-Columbia Region to the point that these populations can be self-sustaining, supporting harvest, while maintaining genetic and ecologic integrity. This objective can be broken into four sequential strategies: (a) maintain critically depressed populations in a manner that avoids jeopardy of extinction, (b) achieve sufficient natural productivity to delist populations listed under the federal

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4 *The term "Mid-Columbia Mainstem Conservation Plan" in this document has no significance other than to allow development of a multi-party hatchery program There will be one settlement agreement and habitat conservation plan for each FERC license in the Mid-Columbia Region.*

5 *A full discussion of No Net Impact is provided in the settlement agreements.*

6 *A definition of this, and other terms, is provided in Appendix A. Defined terms are underlined the first time they are used in the text.*

7 *The Mid-Columbia Region is defined as the mainstem Columbia River and its tributaries upstream of the Yakima River to the tailrace of Chief Joseph Dam.*

8 *Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams*

9 *The MCMCP is being jointly developed by the Mid-Columbia Public Utility Districts (Douglas, Chelan, and Grant) and the Joint Fishery Parties--the U. S. Fish and Wildlife Service (USFWS), the U. S. National Marine Fisheries Service (NMFS), the Washington Department of Fish and Wildlife (WDFW), the Colville Confederated Tribes (CCT), the Yakama Indian Nation (YIN), and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR). Their designated members of the HWG are listed in Appendix B.*

Endangered Species Act (ESA) or to avert listing of candidate populations, (c) seed accessible habitats, and (d) provide for treaty and non treaty fishery objectives.

(2) To compensate for a 7% per project unavoidable loss as needed to meet the NNI standard of the MCMCP (Section 1.4), and provide compensation for the original construction impacts of the mid-Columbia River dams in a manner that is consistent with recovery efforts for natural salmonids. The second objective (7% compensation) may be initiated when the first objective (recovery of populations to self-sustaining levels) is achieved.

These objectives were developed to be compatible with each other, and with the requirements under the ESA. The first objective (population recovery) takes precedence in the hatchery program, and will guide the strategies used for mid-Columbia River hatcheries in the initial years (Phase A)[10] of the Mid-Columbia Hatchery Program. Once it appears that the populations have recovered to sustainable levels (based upon several indicators) and if it is possible to do so in a manner that will not place them in jeopardy, hatchery production of these populations will increase to levels required to meet NNI (Phase B production). However, the potential for genetic and ecologic impacts to natural populations will be addressed prior to any increases in hatchery production. The HWG also identified those populations that are presently at sustainable levels of natural production, and are not in immediate jeopardy of extinction. Hatchery production of sustainable populations will be increased in a phased approach to meet NNI in a manner that will not jeopardize natural populations and is presumed to be consistent with the requirements of the ESA. The criteria to be used to identify if and when a population is at sustainable levels is discussed in the Implementation Strategy (Section 1.3.3), and in the individual discussions for each species and population.

The HWG members brought to these discussions a diversity of technical perspectives on the relative importance of demographic and genetic factors in salmonid restoration efforts. For the most part, differences in approach were manifested as disagreements on the identification of management units for restoration efforts, associated consequences to the rate of restoration and probability of success, and impacts of adult strays into non-target natural production areas. The plan presented here represents an attempt by the HWG to accommodate the variety of technical perspectives held by HWG members while providing a coherent strategy for rebuilding salmon populations in the Mid-Columbia Region. To the extent this document is the product of compromise and accommodation of different technical perspectives, it should be viewed as a framework for testing, where possible, assumptions underlying the genetic management concepts of local adaptation and ecological fitness that are inherent to the different technical approaches.

1.2: First Objective: Rebuild Natural Populations

The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.), mandates the conservation of threatened and endangered species in their natural habitats to a level at which they can sustain themselves without further legal protection. Although artificial propagation (including salmon hatcheries) is not a substitute for maintaining healthy self-sustaining populations in a functional ecosystem, the ESA identifies propagation as one of the tools that can be used to assist conservation and recovery of listed species. NMFS (Hard et al. 1992; 58 F.R. 921186-2286) has determined that salmon hatcheries may be used in conservation under ESA when the artificially propagated fish are similar to the listed natural population in

[10] *The terms "Phase A" and "Phase B" pertain to the Mid-Columbia Hatchery Program only, and should not be compared with the phases described in other aspects of the MCMCP.*

genetic, phenotypic, and demographic traits, and in habitat-use characteristics. Two steps are required to artificially propagate the Plan Species[11]:

(1) Identify Plan Species whose natural populations are at high risk. For these species, determine which hatchery populations are similar enough to the natural populations that they can be used in the recovery program. Conduct a risk/benefit analysis to determine whether using artificial propagation is likely to lead to a net benefit to the listed species. If artificial propagation is considered to be beneficial, use a strategy to increase their natural production in a way that minimizes the risk to its ecologic and genetic integrity.

(2) For Plan Species whose natural populations are not at high risk, design a strategy for hatchery production of these populations, coordinated with appropriate harvest managers, which would not jeopardize the reproduction and recovery of natural populations of all Plan Species.

Step one: *Identify Plan Species whose natural populations are at high risk.*
Chinook salmon: In 1995, NMFS concluded that summer and fall chinook salmon *Oncorhynchus tshawytscha* in the Mid-Columbia Region are part of a large Evolutionarily Significant Unit (ESU; defined by the *NMFS Policy on the Definition of Species under the U.S. Endangered Species Act* 56 F.R. 58612-58618). The ESU includes all late-run ocean-type chinook salmon from the mainstem Columbia River and its tributaries (excluding the Snake River) between Chief Joseph and McNary dams (Waknitz et al. 1995). This conclusion was based primarily upon extensive protein electrophoretic data collections, which showed considerable genetic homogeneity within ocean-type chinook salmon in the region (Utter et al. 1995). This is likely a result of past and present interbreedings, <u>broodstock</u> management, and <u>strayings</u> over a continuous run (Waknitz et al. 1995). Ecological and life history information on this population supported these conclusions (Chapman et al. 1994a; Waknitz et al. 1995).

Although these data indicate that summer and fall chinook salmon are within the same ESU throughout the Mid-Columbia Region, the habitat this population uses varies substantially. Spawning and early rearing conditions in the middle Methow River are markedly different from that of the Similkameen River, and both differ from conditions in the Hanford Reach[12]. Furthermore, the NMFS status review for mid-Columbia River summer and fall chinook salmon identified some aspects of existing hatchery programs as a concern for natural populations (Waknitz et al. 1995). The preferred hatchery strategies for summer and fall chinook salmon (Section 2) attempt to encourage local adaptation of this population to these diverse environments. The HWG classified summer and fall chinook salmon as currently at sustainable levels, given existing conditions (Section 1.5).

At this time, NMFS has not publicly ruled on what populations in the Mid-Columbia Region constitute distinct population segments for spring (stream-type) chinook salmon. The overall level of population separation in the Mid-Columbia Region to be employed by NMFS is not known. Two options were developed for separation of spring chinook salmon populations: (1) the classification of Genetic

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[11] *Plan Species are chinook salmon, steelhead, sockeye salmon, and coho salmon.*

[12] *WDFW separates the ocean-type chinook salmon in the Hanford Reach as a different Genetic Diversity Unit from those that spawn in the mid-Columbia tributaries (Marshall et al. 1995; Table 1), based upon geographic distribution and life history, including migration and spawning timing.*

Diversity Unit (GDU)[13] established by WDFW (Marshall et al. 1995; Shaklee et al. 1996), and criteria established in the SASSI analyses (WDF et al. 1993a; Table 1), and (2) a broader aggregation of populations based at the watershed level (i.e., Wenatchee, Entiat, and Methow rivers). The preferred hatchery strategies for spring chinook salmon (Section 3) therefore attempt to encourage local adaptation of this species to these diverse environments in a way that minimizes genetic and ecologic risks to these populations. The HWG classified spring chinook salmon as not currently at self-sustaining levels, given existing conditions (Section 1.5), and is probably at highest risk of extinction. Given the poor status of this species, many HWG participants believed that a diverse strategy of artificial propagation presented the least risk to the recovery of spring chinook salmon.

Steelhead: NMFS considers steelhead *O. mykiss* in the mid-Columbia River upstream of the Yakima River confluence to be one ESU, and warrant protection under the ESA (61 F.R. 960730210-6210-01). This ESU includes steelhead spawning in the Wenatchee, Entiat, Methow, and Okanogan watersheds, and smaller tributaries to the mid-Columbia River. Only anadromous forms of steelhead are listed due to uncertainties regarding the status of resident forms of *O. mykiss*, and their relation to the anadromous form. Steelhead produced from Wells FH are listed because NMFS considered them essential to the recovery of natural populations.

Contemporary productivity of natural steelhead populations in the Mid-Columbia Region appears to have fallen well below self-sustaining status. Estimated <u>Natural Cohort Replacement Rates</u> for the run above Priest Rapids Dam averaged 0.33 for the 1982-1990 brood years (Brown 1995). This was the principle reason the HWG classified steelhead as not currently at self-sustaining levels, given existing conditions (Section 1.4).

The immediate objective for hatchery production of steelhead (Section 4) will be to recover naturally producing anadromous populations to sustainable levels, with a long term goal of achieving NNI. The production plan provided here proposes further separation for steelhead, by using artificial propagation strategies that encourage local adaptation and distinctiveness in several populations. This strategy is consistent with separations proposed in the SASSI and GDU analyses (Table 1).

Sockeye salmon: The NMFS Biological Review Team (BRT) for sockeye salmon *O. nerka* recommended that the Okanogan and Wenatchee populations would constitute separate ESUs, and should be managed as such (BRT draft 1996). The BRT stated that the sockeye salmon spawning aggregations in the Similkameen, Methow, and Entiat rivers are most likely wanderers from the Okanogan population, and are considered part of that ESU. This decision was consistent with the SASSI and GDU analyses (Table 1). The HWG classified sockeye salmon as currently at sustainable levels, given existing conditions (Section 1.4). The preferred hatchery strategies for sockeye salmon (Section 5) therefore will work towards meeting NNI, based upon increased production of these two distinct population segments in a manner that will not place them in jeopardy.

Coho salmon: All populations of coho salmon *O. kisutch* in the Mid-Columbia Region are extinct. Mullan (1984) estimated the historical populations of coho salmon in the Mid-Columbia Region as follows: 6,000 - 7,000 for the Wenatchee River, 9,000 - 13,000 for the Entiat River, and 23,000 - 31,000 for the Methow

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13 *Note that there is not consensus within the HWG that the GDU designations (shown in Table 1) are discrete population segments.*

River. Although no historical coho salmon population estimates are available for the Okanogan River, coho salmon have occasionally been observed there in some recent years.

Several parties are developing plans to reintroduce coho salmon to the Mid-Columbia Region. This effort is beyond the scope of the Mid-Columbia Hatchery Program. However, coho salmon are included as a Plan Species in the MCMCP, and efforts will be made within the scope of the MCMCP to mitigate for losses of coho salmon originating from the mid-Columbia Region from any reintroduction effort (described in sections 1.4.4 and 6). The efforts done under the authority of the MCMCP will be done in a manner which does not jeopardize the conservation and recovery of other Plan Species.

Table 1. Discrete salmonid population segments within the Mid-Columbia Region, based on assessments in SASSI (WDF et al. 1993a, b) and the WDFW Genetic Diversity Unit (GDU) classification (Busack and Shaklee 1995).

Analysis	Species	Race	Population segments
SASSI	Chinook salmon	Fall	(1)Hanford Reach
		Summer	(1)Wenatchee, (2)Methow, (3)Okanogan
		Spring	(1)Chiwawa, (2)Nason, (3)Little Wenatchee, (4)White, (5)Entiat, (6)Methow, (7)Twisp, (8)Chewuch, (9)Lost
	Steelhead	Summer	(1)Wenatchee, (2)Entiat, (3)Methow/Okanogan
	Sockeye salmon		(1)Wenatchee, (2)Okanogan
GDU	Chinook salmon	Fall	(1)Hanford Reach
		Summer	(1)Upper Columbia
		Spring	(1)Upper Columbia
	Steelhead	Summer	(1)Upper Columbia
	Sockeye salmon		(1)Wenatchee, (2)Okanogan

The Mid-Columbia Hatchery Program will concentrate on strategies that encourage local adaptation of the supplemented populations and increased productivity to compensate for unavoidable losses at the hydroelectric projects. This practice is consistent with NMFS guidelines for artificial propagation under the ESA: *To reduce the potential risk* [of genetic changes or reduced natural productivity] *to the listed species, the use of artificially propagated fish to supplement a listed natural population should be held to the minimum necessary for sustained recovery* (Hard et al. 1992). After review of their operation and evaluation plans, the HWG felt that the existing supplementation programs in the Mid-Columbia Region (Rock Island Fish Hatchery Complex and Methow FH) can further reduce the potential for genetic and ecologic impacts to listed species. For listed populations not currently supplemented, the options in this production plan adhere to the RASP (1992: Part III) guidelines for program development, on the assumption that it is also consistent with NMFS policy. The genetic and ecologic assessments for this strategy are discussed in Sections 1.6 and 1.7, and in each section for the individual species.

Step two*: For Plan Species whose natural populations are not at high risk, design a strategy for hatchery production of these populations, coordinated with appropriate harvest managers, which would not jeopardize the reproduction and recovery of natural populations of the Plan Species.*

As stated in Section 1.1, an objective for artificial propagation under the Mid-Columbia Hatchery Program is to contribute to NNI, and thereby also to provide opportunities for fisheries. Production programs were therefore developed for compensation of Plan Species (Section 1.3). The strategies were developed to be consistent with the NMFS interim policy on artificial propagation under the ESA (58 F.R. 921186-2286): artificial propagation of unlisted species must . . . *not impede the recovery of listed species* . . . *and the deleterious effects of artificial propagation should be minimized by avoiding stock transfers, restricting broodstock to local populations,* [and] *modifying the culture practices so that they do not induce genetic changes that can disrupt the genetic integrity of other populations* . . .   To reduce the potential for deleterious effects on listed species, artificial propagation procedures for species in areas that may be important to the viability of listed species should be coordinated to minimize the effects and monitored to ensure that this is the case (Hard et al. 1992). Analyses of the potential effects of this component of the Mid-Columbia Hatchery Program on listed species and on natural populations of the self-sustaining species are in sections 1.6 and 1.7, and in the sections on the individual species.

While the principal objective of the proposed Mid-Columbia Hatchery Program is to provide the mechanism for those populations listed as “threatened” or “endangered” under the ESA to become self-sustaining (as defined by Hard et al. 1992; Section 1), another important objective of the Mid-Columbia Hatchery Program (and those programs established through previous mid-Columbia settlement agreements) is to strengthen runs so they can support fisheries in the Mid-Columbia Region (for example, see WCC 1995). Accordingly, artificial propagation aimed at recovery of high risk populations would not unnecessarily constrain the use of artificial propagation to maintain and increase harvest opportunities.

## 1.3:	Second Objective: No Net Impact

As discussed in Section 1.1, one objective of the Mid-Columbia Hatchery Program is to numerically compensate for salmonid mortalities at the five mid-Columbia River dams. It is assumed that, during Phase A (Table 5), full NNI compensation will be met when the hatchery and habitat measures replace 7% and 2%, respectively, of the baseline compensation levels (However, quantification of the 2% habitat-based compensation program will not be done; refer to the Mid-Columbia Habitat Program document for a description of that program’s objectives). No Net Impact for all Plan Species will be done in a phased approach, and done in a manner that ensures a high likelihood for meeting the first objective: rebuilding natural populations. The Mid-Columbia Hatchery Coordinating Committee will assess the status of the populations to be affected by all steps taken to achieve NNI, and may defer additional hatchery production if they believe the risk to the natural populations is high.

### 1.3.1:	Interim production objectives

Initial hatchery production objectives are based upon agreed “plug numbers” (described below) which represent baseline compensation levels for the Mid-Columbia Hatchery Program. As average run sizes increase during the course of the MCMCP, total hydropower-caused mortalities will likely increase proportionally. Therefore, the numerical production objective may increase to compensate for a larger number of passage mortalities to the larger smolt outmigrations. Additional facilities may be required, if the numerical compensation objective exceeds the capacity of the existing facilities. However, ongoing analyses of hatchery release to adult return rates may also affect the production objective. Conceivably, continual modifications to the existing facilities will increase the survival of smolts released from the Mid-Columbia hatcheries. This potential improved performance will adjust the production objective downward. Ultimately, production objectives will be adjusted to meet NNI, according to actual survival rates through the mainstem hydroelectric projects.

The hatchery compensation requirement will be adjusted during the course of the MCMCP, requiring several phases of implementation. The hatchery compensation objective will be based upon rolling five-year average adult run sizes for each species at each project (described in Section 1.3.2). The Phase A hatchery production goals are in addition to, and incorporated with the programs under the Rock Island and Wells settlements, and additional production for the dams with less extensive species coverage in their compensation programs established through the Federal Energy Regulatory Commission (FERC): Rocky Reach, Wanapum, and Priest Rapids. Both Wells and Rock Island dams have fully compensated for inundation and downstream passage losses. This production plan therefore addresses the requirements for Rocky Reach, Wanapum, and Priest Rapids dams. Increases in hatchery production will be evaluated for potential genetic and ecologic impacts to the listed species. Appendix C lists current production objectives and capabilities of existing hatcheries in the Mid-Columbia Region.

Plug Numbers:

To identify interim levels of compensation for the Mid-Columbia Hatchery Program, the HWG adopted the recent hatchery production increases provided through the Rock Island and Wells settlement agreements as the Phase A NNI requirements for those projects. In addition, the HWG used the adult survival baselines which had been applied to the Rock Island and Wells Settlement Agreements under FERC (Table 2) to compute the Phase A NNI requirements for the Rocky Reach and Priest Rapids projects. The computation was as follows: using these adult survival baselines, the HWG then applied historical juvenile to adult survival rates to the mid-Columbia River from existing salmon and steelhead hatcheries in the region. These averages encompassed the release years 1980 - 1990 for chinook salmon, 1990 - 1991 for sockeye salmon, and 1984 - 1992 for steelhead (Table 3). The production objective (Table 4) is the quotient of the run size for a given species at those projects (Table 2) and the historical release to adult survival rate (Table 3), multiplied by 7% increased production required to meet Phase A NNI. For example, the hatchery production requirement to meet NNI for spring chinook salmon at Rocky Reach Dam would be:

Baseline returns (Table 2)		*Survival rate (Table 3)*	*NNI component*		*Hatchery production (Table 4)*	
3,761 adults	÷	0.003 adults/smolt	x	0.07	≈	90,000 smolts

Table 2. Baseline run sizes of salmon and steelhead to the Mid-Columbia River, used for determination of Phase A compensation levels.

		Run size at specific points	
Species	Time period	Priest Rapids Dam	Rocky Reach Dam
Spring chinook salmon	1973 - 1982	12,808	3,761
Summer chinook salmon	1974 - 1983	17,879	7,736
Fall chinook salmon	1974 - 1983	8,872	1,265
Sockeye salmon	1973 - 1984	57,104	30,293
Steelhead	1973 - 1982	7,325	4,256

Table 3. Historical survival rates of salmon and steelhead released from Mid-Columbia River hatcheries.

Species	Life stage at release	Size at release (Fish per pound)	Release to adult survival rate (%)
Spring chinook salmon	Yearling	15	0.3
Summer chinook salmon	Yearling	10	0.3
Fall chinook salmon	Yearling	10	0.5
Fall chinook salmon	Subyearling	40 - 50	0.12
Sockeye salmon	Unknown	20	0.7
Steelhead	Yearling	8	1.0

Table 4. Hatchery production goals (based on each hydroelectric project) for Phase A of the Mid-Columbia Mainstem Conservation Plan.

Species	Current production objective[1] Priest Rapids/ Wanapum	Rock Island	Rocky Reach	Wells	Additional production for Phase A Priest Rapids/ Wanapum[2]	Rocky Reach	Total Phase A production objective[3]
Spring chinook salmon	0	672,000	0	738,000	600,000	90,000	2,100,000
Summer chinook salmon							
yearling production	0	1,840,000	0	320,000	833,000	180,000[5]	3,173,000
subyearling production	0	0	0	484,000	0	0	484,000
Fall chinook salmon[4]							
yearling production	0	0	200,000	0	240,000	18,000	458,000
subyearling production	5,000,000	0	1,620,000	0	1,000,000[6]	74,000	7,694,000
Sockeye salmon	0	200,000	0	200,000	1,143,000	300,000	1,843,000
Steelhead	0	200,000	200,000	480,000	100,000	30,000[5]	980,000
Totals	5,000,000	2,912,000	2,020,000	2,222,000	2,916,000[7]	662,000	15,732,000

[1] *Actual numbers of fish produced in a given year may not equal the production objective (Appendix C).*

[2] *Production numbers for Priest Rapids/Wanapum dams account for the combined compensation requirement.*

[3] *The total production objective for Phase A includes the current program capacity plus the additional production required for the Priest Rapids/Wanapum and Rocky Reach projects.*

[4] *The production plans will select yearling and/or subyearling production for fall chinook salmon at specific sites. These numbers are not additive.*

[5] *The additional summer chinook salmon and steelhead production objectives for Rocky Reach is being met under the current production program, therefore no additional production will be required in Phase A.*

[6] *Up to 25,000 lbs (1,250,000 subyearling smolts at 50 fpp) of the current production at Priest Rapids FH may be applied to the Phase A production objectives for Grant PUD.*

[7] *This value is based upon the total yearling fall chinook salmon production.*

1.3.2: Adjustment of hatchery objective to achieve NNI

As discussed in Section 1.3.1, the interim hatchery production objective to achieve NNI will be adjusted, based upon several factors, predominantly the rolling five-year average run size, and average release to adult survival rates. The following describes the method to be used to calculate the hatchery production capacity:

1) Calculate a five-year running average adult run (by species and project; Ays) as follows:

$$Ays = \frac{Ay + Ay\text{-}1 + Ay\text{-}2 + Ay\text{-}3 + Ay\text{-}4}{5}$$

Where Ay is the total adult count for each species at each project in year y:
Ay-1 = the same in the previous year (y-1) and so on.

2) Calculate the five-year rolling average hatchery release to adult return rate SARys for the same period:

$$SARys = \frac{SARy + SAR\text{-}1 + SAR\text{-}2 + SAR\text{-}3 + SAR\text{-}4}{5}$$

3) Divide Ays by SARys to derive the production objective Pys:

$$Pys = (Ays\ 1\text{-}5)/(SARys\ 1\text{-}5)$$

This analysis will be done annually beginning in year 5. When the adjusted production objective for an individual species exceeds 110% of the previous production objective, and the existing hatcheries that can produce that species are operating at capacity, then additional facilities to produce that species will be constructed. If the adjusted production objective is less than 110% of the previous production objective, no action will be required to increase production capacity. If steps 1 through 3 indicate an increase in hatchery fish, the health of the natural population should be considered before implementing additional artificial propagation.

Grant PUD will begin counts of adults at Wanapum Dam in the Mid-Columbia Mainstem Program. It is expected that adult counts past Wanapum Dam will differ from those currently made at Priest Rapids Dam, resulting in an adjusted production objective for Wanapum Dam. This adjustment will be based upon analysis of a 5-year average count of each species at Wanapum Dam.

1.3.3: Implementation strategy

To ensure that the Mid-Columbia Hatchery Program is effective, an implementation strategy is provided. This document sets goals for program development, ranks relative priorities among programs, and sets milestones for determining progress toward each goal. This document lists a number of actions suggested to achieve the goals, but the feasibility of these actions will require further evaluation. Other actions not presently anticipated may be pursued later in the implementation of these programs. There will be no established dates for completion of Phase A because of the indefinite nature of the criteria used for completion. However, the HWG fully anticipates that transition from Phase A to Phase B for the high risk species (spring chinook salmon and steelhead) will require at least two complete generations (8 to 10 years) for analysis of recovery. The transition period for summer chinook salmon and sockeye salmon may proceed more rapidly, depending upon several factors (discussed in each section).

The overall strategy to implement increased hatchery production in the Mid-Columbia Region under the Mid-Columbia Hatchery Program will identify distinct phases, with well-defined criteria for graduation from one phase to the next. Phases are roughly based upon whether or not the species is considered to be self-sustaining given current conditions. For those species that are not self-sustaining (spring chinook salmon and steelhead), Phase A efforts will work to stabilize those distinct populations that appear to be declining. Phase B will increase production of selected populations to make progress toward NNI (Table 5). Programs with existing infrastructures would receive priority, and be immediately modified to meet their assigned management objectives. Current programs (Table 5), and other hatchery programs in the Mid-Columbia Region, may be modified to supplement additional populations. Acclimation sites for reprogrammed hatcheries could be built. For those species that are self-sustaining (summer chinook salmon and sockeye salmon), production will be increased during Phase A to make progress toward the NNI objective in a manner that is consistent with conservation of low risk natural populations and recovery of listed species. A phased approach for both species will be used to minimize deleterious impacts of collecting the donor broodstocks upon the natural populations, and to allow sufficient monitoring of program development.

The time required for high risk species to begin Phase B compensation will be significant; in a best case situation of optimum ocean conditions and full implementation of recovery measures provided in the MCMCP, recovery of spring chinook salmon and steelhead to self-sustaining levels would take no less than two or three salmonid generations. Because many of the measures to be provided in the MCMCP require a significant amount of time to fully develop, a longer time frame of four to five salmonid generations is probably a realistic expectation for initiation of Phase B compensation programs. For those species that are not self-sustaining (spring chinook salmon and steelhead), abundance levels and natural productivity will be the established criteria to determine when natural population levels are stabilized. Natural Cohort Replacement Rates will be used to estimate changes in natural productivity, and thereby allow initiation of Phase B production. The numerical derivations for this criterion are based upon delisting criteria for Snake River chinook salmon (Bevan et al. 1994; NMFS 1997).

To initiate Phase B, the Natural Cohort Replacement Rates for each species should achieve a geometric mean greater than 1.0 over at least two generations (approximately eight years). This will be measured by the composite run sizes of adults past Rock Island and/or Priest Rapids dams, adjusted for upstream passage mortalities from those projects to the spawning grounds, minus the hatchery adults that were produced to mitigate for losses at Grand Coulee Dam. To ensure that a distribution goal is met for spring chinook salmon and steelhead, this objective must be in 80% of the index areas where a Natural Cohort Replacement Rate can be estimated. Two population-level criteria could be used in lieu of, or in addition to dam counts to determine abundance: (1) redd counts of streams where spring chinook salmon spawn, and selected index streams for steelhead, and (2) parr or smolt production values for selected index streams for each species, particularly steelhead, where redd counts are not feasible or reliable. These criteria will be evaluated annually. The decision on whether the criteria indicate the appropriate time to initiate Phase B will be made by Mid-Columbia Hatchery Coordinating Committee.

Table 5. Outline of the implementation strategy for the Mid-Columbia Hatchery Program, with criteria for completion of phases. The phases for each species are discussed in detail in their respective sections.

Species	Phase	Criteria for completion
Summer/fall chinook salmon	A	Production at existing facilities will be at capacity, and development of additional acclimation sites will be completed. Analyses of yearling and subyearling production programs will be made to determine the appropriateness of each strategy for long-term production.
	B	Full compensation will have been met.
Spring chinook salmon	A	Populations are stabilized at self-sustaining levels, and development of additional acclimation sites will be completed. A strategy to collect appropriate broodstock will have been established.
	B	Full compensation will have been met.
Steelhead	A	Populations are stabilized at self-sustaining levels, and development of additional acclimation sites will be completed. A strategy to collect appropriate broodstock will have been established.
	B	Full compensation will have been met.
Sockeye salmon	A	Initial production of the Okanogan Population will be based upon strategies that ensure adult returns only to Washington State, until the transboundary issue is resolved.
	B	Full production of the Wenatchee Population will meet NNI in a manner that meets county and state development and water quality standards. Full production of the Okanogan Population will meet full compensation in a manner that is consistent with Canadian federal, provincial, and tribal governments.
Coho salmon	A	Compensation for passage mortalities at the five Mid-Columbia River dams will begin when coho salmon are successfully reintroduced to the region.
	B	Compensation will be based upon the average adult returns to the Mid-Columbia Region.

1.4: Individual Project Commitments

The Mid-Columbia PUDs currently own seven main hatcheries and numerous satellite facilities that compensate for project impacts. Programs were developed using these facilities to meet specific compensation objectives developed through FERC Settlement Agreements. Each year, the PUDs review these programs with the JFP on issues such as mitigation compliance, funding, maintenance, and operations. In addition to meeting FERC relicensing requirements, these facilities have been operating under Section 10 permits for incidental take of listed Snake River chinook and sockeye salmon under the ESA. The objectives of these hatcheries under those Section 10 permits include (1) produce fish in accordance with the specific goals of each hatchery; (2) minimize interactions with other fish populations through proper rearing and release strategies; (3) maintain population integrity and genetic diversity of each propagated population; (4) maximize survival at all life stages using disease control and prevention techniques; (5) conduct environmental monitoring to ensure that hatchery operations comply with water quality standards and to assist in managing fish health; and (6) communicate effectively with other fish producers and managers in the Columbia River Basin. Chelan and Douglas PUDs will continue to meet their commitments, and in Phase A of the Mid-Columbia Hatchery Program, will meet the commitments established below.

1.4.1: Douglas PUD commitments

Douglas PUD fulfills its hatchery production requirements for FERC and MCMCP through construction and operation of Methow FH for spring chinook salmon, Wells FH for summer chinook salmon and steelhead, and the Cassimer Bar FH pilot program for sockeye salmon. These programs are for both passage and inundation losses. Douglas PUD will continue these commitments during Phase One[14] of the Mid-Columbia Mainstem Program. If it is determined that these facilities produce more or less than the established compensation requirement, Douglas PUD will adjust the hatchery production accordingly.

Douglas PUD built Methow FH in 1992 to compensate for passage mortalities of spring chinook salmon at Wells and Rock Island dams. This facility operates on the supplementation concept--broodstocks are collected on the Methow River and progenies are acclimated to the natal streams prior to volitional release (WCC 1995). Methow FH was designed to operate as a supplementation facility (RASP 1992) with a production objective of 738,000 yearling smolts[15] (450,000 smolts to compensate for Wells Dam passage mortalities and 288,000 smolts for Rock Island Dam passage mortalties). Methow FH produces less than full capacity if such a strategy is consistent with the conservation and recovery of Plan Species.

Wells FH was built by Douglas PUD in 1967 to mitigate for loss of summer chinook salmon spawning area inundated by Wells Dam. Originally built as a spawning channel, it was reprogrammed to serve as an extended rearing facility in 1977. Under the Wells Settlement Agreement, it now produces both 484,000 subyearling (24,200 lbs. at 20 fpp) and 320,000 yearling (32,000 lbs. at 10 fpp) summer chinook salmon (Section 2) to compensate for inundation. Douglas PUD compensates for summer chinook salmon passages losses at Wells Dam through the Rock Island Fish Hatchery Complex (Section 1.4.2).

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14 *In this context Phase One pertains to mainstem passage measures in the MCMCP, and should not be confused with Phase A of the Mid-Columbia Hatchery Program.*

15 *As designed, Methow FH is capable of rearing 738,000 yearling smolts to 15 fpp, while not exceeding a density of 0.75 lbs. / cu. ft. The capacity to rear sequential brood years is reduced to 550,000 smolts when fish are held at a density index of 0.125 lbs. / cu. ft/ inch at all juvenile life stages.*

Wells FH also produces 480,000 steelhead smolts for scatter plants in the lower Methow River, the lower Similkameen River, and lower Omak Creek (Section 4). The steelhead production allocates 30,000 lbs (180,000 smolts at fpp) for passage and 50,000 lbs (300,000 smolts at 6 fpp) for inundation losses as a result of Wells Dam.

Cassimer Bar FH is an experimental facility which began operation in 1992 to compensate for passage mortalities of sockeye salmon at Wells Dam. This facility is funded by Douglas PUD and operated by the Confederated Colville Tribes. This pilot project started in 1992 to produce 200,000 fish (8,000 lbs. at 25 fpp), to be released in the spring as subyearlings from nets pens in the lower basin of Lake Osoyoos (Section 5). Douglas PUD plans to use an experimental program at Rufus Woods Reservoir with the same poundage in lieu of the Lake Osoyoos Program until the transboundary production issue is resolved (Section 5.7). After Phase A, if neither the Lake Osoyoos or Rufus Woods programs appear feasible, Douglas PUD will eliminate the sockeye salmon production and add 150,000 (15,000 lbs. at 10 fpp) yearling and 260,000 (6,500 lbs. at 40 fpp) subyearling summer chinook salmon.

1.4.2: Chelan PUD commitments

Rock Island Dam

Chelan PUD built the Rock Island Fish Hatchery Complex (RIHC) in 1989 and funds its operations to compensate for unavoidable passage losses at Rock Island and Wells dams. Eastbank FH is the central rearing facility and annually produces up to 2,800,000 yearling chinook salmon, steelhead, and sockeye salmon. This compensation level was calculated to replace fish killed at Rock Island Dam prior to completion of bypass systems. The unmitigated losses following completion of bypass systems will be determined through juvenile survival studies, and will be adjusted accordingly. If it is determined that the RIHC program exceeds the compensation requirements for Rock Island Dam, the surplus production capacity will be credited toward Rocky Reach compensation.

In consideration of biological efficiency and logistical effectiveness, Douglas PUD and Chelan PUD have agreed in their respective settlement agreements for Wells and Rock Island dams that (1) Douglas PUD assumes responsibility for 19,200 lbs. (288,000 smolts at 15 fpp) of Methow spring chinook salmon production to compensate for passage losses at Rock Island Dam and (2) Chelan PUD assumes responsibility for 40,000 lbs. (400,000 smolts at 10 fpp) of Methow summer chinook salmon production to compensate for passage losses at Wells Dam (this is described in detail in the Wells Settlement Agreement). This exchange will continue in the Mid-Columbia Hatchery Program. Other exchanges will be considered if they are biologically appropriate and mutually beneficial to the PUDs.

Rocky Reach Dam

Three hatchery programs (Chelan, Rocky Reach, and Turtle Rock) were built and are funded by Chelan PUD to compensate for loss of summer and fall chinook salmon and steelhead due to inundation of habitat and downstream passage losses by Rocky Reach Dam. The original mitigation requirements were construction of a spawning channel (Turtle Rock) for summer and fall chinook salmon and a hatchery program for steelhead (Chelan FH). The spawning channel commitment has since been changed to a hatchery program of 1.62 million subyearling summer fall chinook salmon. In addition, interim settlement agreements (1984 stipulation) established a yearling fall chinook salmon program of 200,000 to compensate for passage losses (Section 2). The steelhead compensation allocated 165,000 fish for inundation losses and 30,000 fish for passage losses (195,000 total requirement, adjusted to 200,000; Section 4).

Under the MCMCP, Chelan PUD will continue these programs to meet some of the compensation requirements for Rocky Reach Dam. In addition, the following measures will be undertaken in Phase A of the Mid-Columbia Hatchery Program:

Spring chinook salmon: It is assumed that some of the spring chinook salmon production commitment for Rock Island program will be transferred to the Rocky Reach program, and thereby meet Chelan PUD's overall spring chinook salmon requirements (Table 4). If production in addition to or in lieu of transfers from the Rock Island Program is required to fulfill the Rocky Reach Program, Chelan PUD will pursue the following options: (1) transfer production responsibility from Douglas PUD for up to 90,000 yearlings at Methow FH, or (2) participate in the renovation or expansion of either Entiat NFH or Winthrop NFH to increase the productivity of their spring chinook salmon programs, (3) participate in the expansion of production capacity and/or productivity increases for Methow FH, or (4) participate in the development of new facilities and programs which supplement spring chinook salmon production upstream from Rocky Reach Dam.

Summer and fall chinook salmon: Rocky Reach FH works in conjunction with the Turtle Rock Satellite, where the fish undergo final rearing and release. These programs will be modified to meet the conservation/supplementation standards outlined in this document to be consistent with recovery efforts for Plan Species (this strategy is discussed in Section 2). It is assumed that some of the summer and fall chinook salmon production commitment for Rock Island program will be transferred to the Rocky Reach program, and thereby meet Chelan PUD's overall summer and fall chinook salmon requirements (Table 4). If production in addition to, or in lieu of transfers from the Rock Island Program is required to fulfill the Rocky Reach Program, Chelan PUD will pursue the following options: (1) expand the production capacity and/or increase productivity for Rocky Reach FH and the satellite release facilities which may be developed to support Rocky Reach FH, or (2) participate in the expansion of production capacity and/or productivity increases for Wells or Eastbank fish hatcheries above the Wells Program, or (3) participate in the development of new facilities and programs which supplement summer chinook salmon production upstream from Rocky Reach Dam.

Steelhead: Chelan FH was renovated in 1964/65 and now operates to compensate for losses incurred as a result of Rocky Reach Dam. To meet the conservation standards outlined in this document for Plan Species, Chelan FH will convert operations to a supplementation concept (the strategy for steelhead supplementation is discussed in Section 4).

Sockeye salmon: Chelan PUD will participate in the development of an acceptable alternative(s) for supplementing the production of Okanogan sockeye salmon above Wells Dam. There are currently two alternatives being assessed: (1) a net pen production program using Rufus Woods Reservoir for a portion of the rearing cycle (Section 5.7) and (2) production reared and/or released in the north basin of Lake Osoyoos. This second option is constrained by the requirement for the Mid-Columbia Hatchery Coordinating Committee to resolve a dispute with the federal and provincial governments of Canada over hatchery-based production of sockeye salmon. In addition, modification of spawning and/or incubation habitat within the Canadian sections of the Okanogan River may provide increased productivity for this population. Chelan PUD will select and pursue an alternative to achieve the Rocky Reach production goals (Table 4) as soon as practicable.

1.4.3: Combined PUD commitments

The Mid-Columbia PUDs are not responsible for reintroduction of coho salmon to the Mid-Columbia Region (Section 6). However, they will participate in the compensation for the coho salmon originating in the Mid-Columbia Region from any reintroduction program. The initial compensation will be based on a 5-year average of returning adults. Thereafter, production adjustments will be based upon the criteria established in Section 1.3.2. It is anticipated that this could include development of one or two acclimation ponds in the Methow Watershed and an acclimation pond in the Wenatchee Watershed.

The initial compensation will be based on a 5-year average of returning adults. There is no useful historical survival rate for coho salmon released from Mid-Columbia River hatcheries to determine a hatchery production requirement, such as has been done for the other species (Section 1.3.1 and Table 3). However, a release to adult survival rate of 0.3 percent was considered by the HWG to be a minimum average level required of future hatchery programs to be considered successful for achieving NNI. Determination of the coho salmon hatchery production requirement will therefore follow the formula in Section 1.3.1, using a 0.003 adults/smolt survival rate. Thereafter, production adjustments will be based upon the criteria established in Section 1.3.2, using applicable coho salmon release to adult survival rates from new Mid-Columbia hatchery programs, provided that those survival rates meet or exceed 0.3 percent.

1.5: Risk Assessment

An important function of this document is to identify the potential risks to the natural populations from the proposed Mid-Columbia Hatchery Program and to identify measures to reduce these risks. The following subsection outlines the process the HWG used to identify these risks and measures. Prior to developing a production plan, the HWG deliberated whether supplementation was an appropriate tool to recover natural populations of anadromous salmonids in the Mid-Columbia Region. Supplementation of anadromous salmonids can potentially benefit only those populations where natural smolt production is limited by adult escapement, not spawning or rearing habitats (Steward and Bjornn 1990). Supplementation has limited potential to maintain or enhance natural genetic diversity (Bowles 1995), and has a major risk of discouraging among-population and within-population variability (Busack and Currens 1995). However, supplementation may be an important recovery tool in areas where local populations are not currently self-sustaining, assuming the problems that caused the decline are addressed (RASP 1992; Cuenco et al. 1993). One goal of the Mid-Columbia Habitat Program is to protect and restore critical habitats for salmon and steelhead within the Mid-Columbia Region (Bugert et al. 1997a). The Mid-Columbia Hatchery Program will therefore work in concert with that program.

Many streams in the Mid-Columbia Region have critically low escapements, to the point that localized extinction is imminent, or currently have no anadromous salmonid production because of human-made passage barriers. Hatchery production strategies under the Mid-Columbia Hatchery Program therefore focus on supplementing populations where: (1) adequate spawning and rearing habitats are available, or (2) additional stream habitat has been made available through the Mid-Columbia Habitat Program.

While it is generally recognized that some deleterious effects of supplementation may occur to natural populations (Ryman and Laikre 1991; Bowles 1995), specific hatchery strategies can be used to reduce these risks. Genetic protection elements for additional hatchery programs in the Mid-Columbia Hatchery Program follow those generally outlined in Hard et al. (1992), Kapuscinski and Miller (1993), and Busack and Currens (1995). Carefully developed hatchery operation and evaluation programs, such as those developed for the Rock Island Hatchery Complex (RIHC) and the Methow Basin Spring Chinook Salmon Supplementation Plan (MSP), will be a component of the Mid-Columbia Hatchery Program to identify the hazard of each hatchery program to the listed species, and the means to quantify this risk (Busack and Currens 1995). However, equally important to an effective hatchery operation and evaluation plan is to determine, *a priori*, what level of risk is unacceptable, and what (if any) potential measures can be done to mitigate or rectify that hazard. If no measures can be identified, the overall risk of a hatchery program must then be weighed against the alternative--support to that population solely through passage improvements and habitat restoration.

To assess the relative risk of recovering listed populations with and without supplementation, the HWG individually assessed the probabilities for population status of steelhead and spring chinook salmon within 10 and 50 years. These assessments were compiled (Appendix D) and used to determine the need for hatchery intervention as a tool for the recovery of these populations under the ESA. In addition, the HWG assessed the population separations identified in SASSI, and developed functional groupings for hatchery production, based upon available genetic, demographic, and ecologic data (Appendix E). The work group believed it is likely that given existing conditions, mid-Columbia River steelhead and spring chinook salmon populations were at a high risk of extinction if no hatchery intervention was made (Table 6). It should be noted however, that this assessment was based primarily upon the professional judgement of the HWG participants, and was made without consideration of the potential benefits to natural production of the Mid-Columbia Habitat Program.

Table 6. Estimated probabilities that mid-Columbia River populations of steelhead and spring chinook salmon will be extinct, or nearly extinct, within 10 and 50 years, given existing conditions and no hatchery supplementation. Response number indicates how many HWG members participated in the assessment.

Species	Time period	Range across populations	Number of responses
Steelhead	10 years	0.16 - 0.64	8
	50 years	0.37 - 0.78	8
Spring chinook	10 years	0.20 - 0.52	9
salmon	50 years	0.49 - 0.74	9

Based upon this analysis, the HWG assessed the relative risk of all feasible intervention strategies upon each individual population. The "least risk" strategies for all natural populations were identified, and are described in this document. Intervention strategies included in the assessment were: (1) <u>low,</u> <u>medium</u>, and <u>high-level supplementation</u>; (2) <u>captive rearing</u> of salmonids through the entire life cycle, initiated through either juvenile or adult collections; (3) management of two or more distinct population segments into larger composite <u>populations</u>; and (4) infusion of <u>non-native</u> gametes into gene pools of selected hatchery production groups. These strategies were considered primarily for spring chinook salmon and are described in the risk assessment for that species in Section 3.5.

For those species that are considered not to be self sustaining given current conditions (spring chinook salmon and steelhead), the relative risks to these populations of several intervention strategies were analyzed (these proposals are discussed in the appropriate sections). It became apparent to the HWG that a strategy that posed the least risk to one population may present a fairly high risk to another. The "preferred intervention strategy" for spring chinook salmon and steelhead was a combination of strategies that as a whole, provide the highest likelihood of contributing to the recovery of those species that are not currently self-sustaining at the population, basin, and regional level. The HWG believed that a diversified propagation strategy posed the least risk approach for spring chinook salmon (Section 3). Moreover, a diversified approach will allow the Mid-Columbia Hatchery Coordinating Committee to assess the relative effectiveness of the alternative strategies.

Some HWG members advocated that managing discrete populations of spring chinook salmon within a hierarchical framework would increase their rate of rebuilding. Their rationale was that individual local breeding populations within a watershed are connected in a higher level of organization by exchange of individuals on a periodic basis. One or more of the Mid-Columbia watersheds (the Wenatchee, Entiat, or Methow) should be managed as one metapopulation (Hanski and Gilpin 1991), similar to that done for summer chinook salmon in the Mid-Columbia Region (Section 2). From a demographic perspective, the population concept would balance the extinction and recolonization of local breeding populations within a watershed. At that watershed level, individual populations are expected to be similar in demographic and ecologic characteristics so that fish may stray from one population to another, and be equally adapted and contribute to the overall productivity of the populations. From a genetic perspective, the use of a broader scale of population separation reduces the likelihood of inbreeding and genetic drift, and would be most appropriate for genetically similar (and geographically close) populations that are at high risk of extinction.

The HWG established an evaluation plan (Section 1.9) concomitant to the production plan with the perspective that the risks to native natural populations from artificial propagation can be broken into two components:

(1) There are deleterious effects that may be measured in the evaluations and identified in a timely manner, so that the Mid-Columbia Hatchery Coordinating Committee may adapt the production program to lessen the risk. The Hatchery Program would thus undergo continuous adaptive management, based on results of the monitoring and evaluations. Each species has specific uncertainties related to its management; the evaluations must address its unique needs; and

(2) Despite having an extensive evaluations program, there are some deleterious effects that may occur unnoticed. These uncertainties exist because we may not have sufficient statistical power to detect them in a timely manner so that we may respond appropriately. Some HWG members accepted these uncertainties in developing the production plan, and assumed that the benefits of the artificial propagation exceeded the risks. Some of these risks include, but are not limited to: domestication effects and outbreeding depression effects from straying.

One critical uncertainty faced by the HWG was the reproductive success of hatchery-produced fish in the natural environment. This unresolved issue has important implications on the role of artificial propagation to conserve and recover high-risk species, and to increase the abundance of low-risk species in a manner that does not jeopardize their sustainability. The HWG recognized that it was logistically infeasible to evaluate the reproductive potential of all species. However, for at least some species, it may be possible to use recently developed techniques to measure the reproductive success of hatchery fish in the natural environment (e.g. Section 3.7).

1.6: Management Assessment

1.6.1: Terminal area broodstock collection

In the existing supplementation programs in the Mid-Columbia Region, a concerted effort has been made to construct broodstock collection facilities on low-order streams close to where the populations spawn. The purpose of these traps is to meet program broodstock needs in manner that samples the range of genetic variability present in a Plan Species while preserving opportunities to base recovery on its component parts. This is the foundation of the supplementation concept--that which encourages ecologic and genetic fitness--

yet is undoubtably the most difficult objective to meet. Bugert (1996) describes some of the mechanical difficulties in collecting broodstock using terminal area traps.

1.6.2: Water supply for late summer rearing

The number and biomass of salmonids that can be reared at a given facility is directly dependent upon several conditions, including flow, temperature, exchange rate, dissolved oxygen, metabolic waste buildup, the type of rearing container, and the species to be reared (Piper et al. 1982). However, locating an adequate supply of suitable water is probably the single most important criterion in developing an artificial propagation program--particularly in the Mid-Columbia Region. Specific water quality goals were established by IHOT (1995) for spawning, incubation, and rearing salmonids, as a means to ensure proper growth and development, fish health, and the physiological process of smoltification. These goals include water chemistry, dissolved gases, turbidity, alkalinity, nitrite, contaminants, and pathogens (Table 7 lists selected goals--a complete list is provided in the IHOT document). Pathogen-free water is preferred at all facilities that incubate and rear salmonids, as this eliminates the incidence of many diseases. Although not prescriptive, it is recommended that water used for incubation and rearing be single use, with an exchange time that ensures fish health maintenance. The production plans provided in this document use those water quality goals established in IHOT (1993), goals established by Peck (1993a, b), Shelldrake (1993), and Wold (1993; Appendix F) and PNFHPC (1989), and generally follow the loading densities recommended by Banks (1994). All facilities constructed for the Mid-Columbia Hatchery Program will meet or exceed these goals. The strategies outlined in this assessment were based upon the premise that these goals would be maintained.

Table 7. Selected water quality goals established by IHOT (1995) for salmonid propagation.

	Water temperature (°C)			Dissolved	Ammonia
Species	spawning	incubation	rearing	oxygen	(un-ionized)
Chinook salmon	5.6-12.8	5.0-11.7	8.9-12.2	>7.0 mg/l	<0.0125 mg/l
Sockeye salmon	10.6-12.2	4.4-13.3	4.4-13.3	>7.0 mg/l	<0.0125 mg/l
Steelhead	3.9- 9.4	7.2-12.8	8.9-15.0	>7.0 mg/l	<0.0125 mg/l

The water temperature criteria in Table 7 limit the production capability at the major rearing facilities (Priest Rapids, Chelan, Rocky Reach/Turtle Rock, Wells, Leavenworth, Entiat, Winthrop, and Methow hatcheries; Table 8)--particularly in late summer. This in turn, limits the number of yearling salmonids available for transfer to the acclimation sites. A strategy to circumvent this limitation is to release salmonids as subyearlings, prior to the increase in late summer water temperatures at the hatcheries. This strategy is used successfully for ocean-type chinook salmon at Priest Rapids FH, but has not been successful at Wells FH (Bugert et al., in prep). Wells FH and Leavenworth FH also unsuccessfully attempted to rear stream-type chinook salmon on an accelerated schedule for subyearling release, and discontinued that strategy (Sullivan 1992).

Ice/slush accumulations at river intakes may limit winter production (USFWS 1986b; WDFW 1995). At some hatcheries, this prompts a dependence upon reuse water, which aggravates the horizontal transfer of disease, or the development of environmental gill disease. Water aeration and pond cleanings may reduce, but not prevent these problems. The Mid-Columbia Hatchery Coordinating Committee must balance these concerns in implementing new hatchery programs.

Table 8. Water supply and temperatures at major rearing facilities in the Mid-Columbia Region

Facility	Surface water Flow (cfs)	Surface water Temp. range (°C)	Groundwater Flow (cfs)	Groundwater Temp. range (°C)
Colville Tribal FH			13.3	8.3 - 13.3
Cassimer Bar FH			3.6	11.1 - 12.2
Wells FH	171.8	0.3 - 20.0	19.8	8.3 - 11.7
Chelan FH	26.0		16.0	10.6 - 14.4
Rocky Reach FH			6.2	1.7 - 18.3
Turtle Rock FH	44.0	0.3 - 20.0		
Eastbank FH			53.0	7.9 - 13.4
Priest Rapids FH	98.9	0.3 - 20.0	17.6	1.3 - 16.0
Leavenworth FH	40.7	0.5 - 20.0	14.8	- -[a]
Entiat FH	4.0	0.3 - 21.0	0.7	7.3 - 9.5
Winthrop FH	42.4	0.0 - 18.5	14.3	7.3 - 11.2
Methow FH	7.0	0.0 - 18.5	8.9	8.9
Ringold			100.0	14.0 - 15.0

[a] *Temperatures recorded at Leavenworth NFH are combined surface and ground waters.*

Previous studies to identify sites for hatchery production in the Mid-Columbia Region (CH2M Hill 1979; FKA 1981a, b) suggested that few additional sites are available, primarily because of water supply. After a review of selected literature and well log records, FKA (1981a) concluded that locating a hatchery site in the region with water of suitable quality and quantity would be difficult. Since all the Columbia Basin is underlain with basalt, drilling requires deep wells intersecting several basaltic layers to tap large quantities of water. Frequently, water obtained from such wells is too warm or too highly mineralized for use in a hatchery operation (PNRBC 1970, cited in FKA 1981a). After reviewing the results of preliminary groundwater investigations, FKA determined that further efforts to locate additional water sources would be confined to existing hatchery sites and a few selected sites (listed in Table 9). Some of these sites have been developed since the FKA report (notably Colville FH near Chief Joseph Dam), and the other sites were considered for additional hatchery production, but were dismissed because of high water temperatures. It should be noted however, that further hydrologic studies for a given site would likely be required.

Table 9. List of potential hatchery sites in the Mid-Columbia Region, identified by FKA (1981a), with their rating of site quality, based upon availability of suitable water.

Site	Function	Rating
Colockum Creek	Satellite	Acceptable
Lower Crab Creek	Satellite	Poor
Rock Island Creek	Hatchery	Poor
Douglas Creek	Hatchery	Poor
Dryden Canal	Satellite	Poor
Mission Creek	Satellite	Poor
Methow River confluence	Net pens	Good
Chief Joseph Dam	Hatchery/satellite	Good

The Eastbank Aquifer is the largest and most reliable source of suitable groundwater in the Mid-Columbia Region. Located on the east shore of the Columbia River just upstream of Rocky Reach Dam, the aquifer is presumed to be in hydraulic continuity with the river. The Eastbank Aquifer is tapped by a number of wells, including four for Eastbank FH (53 cfs; Table 8), four wells for the City of Wenatchee (up to 80 cfs), and two wells for Lincoln Rock State Park (0.7 cfs). The aquifer's thermal storage capability is used to the hatchery's advantage, by providing cooler water in late summer and early fall, when the need is highest. This supply can be manipulated by increasing the pumping rate of the wells in winter to recharge the aquifer with relatively cold river water. Studies of the Eastbank Aquifer indicated that this thermal storage capability may be adversely affected however, by an increased demand for more hatchery production (W&EST 1990). This effect should be considered if additional late summer rearing at Eastbank FH is anticipated. About 8 cfs of water from the aquifer flows past the grouted cutoff wall at the base of Rocky Reach Dam--most of this water is used at Rocky Reach FH.

The Chief Joseph Dam site (Table 9) has about 30 cfs of water for direct diversion from the seepage relief tunnel. The chemical quality of the water is suitable, and is pathogen free (Anonymous 1977). Because of the time it takes the water to move from Rufus Woods Reservoir through the gravels and discharge tunnel, the temperature of the relief tunnel discharge is out of phase with the ambient air temperature; the highest water temperatures is during winter and lower water temperature occurs in summer: temperature ranges from 8.3^{o} C. to 13.9^{o} C (Anonymous 1977).

There do not appear to be any sources of suitable water to rear additional salmonids in late summer and fall at hatcheries other than Eastbank FH and the Chief Joseph Dam site, although some detailed hydrologic analysis may be required to verify this. In an attempt to increase the amount of groundwater available, Wells FH has developed 13 wells over a twenty-year period, yet suitable rearing water remains as the primary constraint to additional production at that facility (Peck 1993a). Rearing water supply is also listed as a major limitation to production at the following hatcheries: Priest Rapids, Rocky Reach, Turtle Rock (Peck 1993a, b), Leavenworth, Entiat, and Winthrop (USFWS 1986a, b, c). To compound this problem, water supply at a number of facilities are in jeopardy due to declining water tables from increased allocation of groundwater, and contamination from septic systems (WDFW 1995).

Methow FH has both groundwater and surface water supplies. The facility was built with four wells capable of supplying 10.7 cfs (4,800 gpm) of groundwater. Water temperatures are steady at 8.9° C year round. Maintenance on the four wells in 1995 and 1996 showed that the total output of the wells is 8.8 cfs (4,000 gpm). Methow FH also has 7 cfs (3,142 gpm) of surface water that is diverted at Foghorn Irrigation Ditch. This water is used primarily for final rearing, but can be used for any rearing stage after incubation. The water right is held by USFWS. The 7 cfs of water was agreed to between Douglas PUD and USFWS in exchange for improvements to the intake structure of the Foghorn Ditch plus improvements to the ladder at Foghorn Dam. The low brood returns and resultant production of spring chinook salmon over the last few years have freed up some water and pond resources. Steelhead and summer chinook salmon have been held during late summer and fall at the hatchery.

Methow FH also has two acclimation ponds, on the Twisp and Chewuch rivers. Both ponds are used for final rearing and acclimation of smolts to these drainages. The water right for both ponds is for 6 cfs for February 1 through May 31. Water for the Twisp Pond is diverted from the Twisp Valley Power and Irrigation Company ditch. Water for the Chewuch Pond is diverted from the Chewuch Canal Company irrigation ditch. The easement from both canal companies is for delivery of water between February 1 through May 1. Neither site is suitable for late summer rearing because (1) low flow conditions persist in both the Twisp and Chewuch rivers in late summer, plus (2) existing water demands on the irrigation ditches would compete with the acclimation ponds' use.

1.6.3: Columbia River Fish Management Plan

In 1988, a provisional plan was established to rebuild and enhance upper Columbia River fish for treaty Indian and non-Indian fisheries. Parties to the agreement include the Confederated Tribes of the Warm Springs Indian Nation; the Confederated Tribes and Bands of the Yakama Indian Nation, the Nez Perce Tribe; the Confederated Tribes of the Umatilla Indian Nation; the Shoshone-Bannock Tribes;[16] the federal government, acting by and through the Secretary of Commerce and his agents, and the Secretary of Interior and his agents; and the states of Oregon, Idaho, and Washington. This agreement was established pursuant to a settlement in the *U.S. vs. Oregon* litigation (CRFMP 1987).

As part of the settlement agreement, the parties jointly developed, and the federal court adopted, the Columbia River Fish Management Plan (CRFMP) to guide harvest and production management. Among other things, the plan specified harvest guidelines, escapement goals, and production actions for populations of salmon that are produced above Bonneville Dam, including those that enter the Mid-Columbia Region. The CRFMP provided for management goals of 115,000 spring chinook salmon at Bonneville Dam, 65,000 sockeye salmon at Priest Rapids Dam, and 40,000 fall chinook salmon at McNary Dam. The parties subsequently have agreed on a provisional management goal of 80,000 summer chinook salmon at Bonneville Dam. In addition, the parties agreed to restrict fishery impacts on wild steelhead when Bonneville run sizes are less than 75,500 wild adults. The agreement also established a Production Advisory Committee (PAC) to oversee implementation of the production actions called for in the CRFMP and to coordinate annual production planning for state and federal Columbia River hatcheries.

The parties to the CRFMP also agreed to impose voluntary restrictions on harvests in the mainstem Columbia River when upriver runs are less than the Bonneville management goals. Harvest impacts on under escaped runs seldom exceed 5 - 7% to provide for minimal ceremonial and subsistence needs by the tribes and for minor incidental catches in non-treaty fisheries. Commercial fisheries for all salmonid species except fall chinook salmon have been curtailed in recent years; the last commercial harvest of upriver spring chinook salmon occurred in 1977, and the last commercial summer chinook salmon fishery occurred in 1964. Commercial harvest of sockeye salmon have occurred in only six of the past 20 years. Voluntary restriction on harvest impacts to wild steelhead in tribal commercial fall chinook salmon fisheries limit the catch to 15% of the A wild run and 32% of the B wild run, which has resulted in early closures of those fisheries in some years. These fishery restrictions were intended to complement other measures by the parties to increase the production of salmonids in upriver tributaries. Clearly however, some upriver runs have not recovered despite sharp reductions in fishing mortality.

Under the CRFMP, specific goals for artificial propagation were established for the Mid-Columbia Region--these goals may then be adjusted annually by agreement of the *U.S. v Oregon* parties. At this time, Priest Rapids FH, Rocky Reach FH, Wells FH, and the GCFMP Complex (Leavenworth FH, Entiat FH, and Winthrop FH) produce salmon and steelhead to assist in meeting these escapement objectives (although all production in the region is incorporated into the escapement calculations).

[16] *While not a signatory party to the CRFMP, the Shoshone-Bannock Tribes were deemed to be a management entity for certain aspects of the plan, and are members of the Technical Advisory Committee, the Production Advisory Committee, and the Policy Committee.*

The presence of additional hatchery fish in the aggregate run of salmon passing through ocean and inriver fisheries downstream of McNary Dam could lead to increased harvest rates on species listed under the ESA. Harvest management implications of additional hatchery production, whether for recovery purposes or for mitigation, are evaluated by the parties to *U.S. v. Oregon* to ensure that harvest management decisions are consistent with rebuilding listed and other Columbia Basin populations.

1.6.4: Hatchery production ceiling

When hatchery-reared salmon and steelhead smolts intermingle with listed salmon and steelhead smolts in the Columbia River migration corridor, there are potential density-dependent adverse effects. These effects include disease transmission, predation, and competition for food and space. In order to address the question of ecological carrying capacity of the Columbia River migration corridor and of the estuarine and marine ecosystems, and to minimize overall density-dependent effects of hatchery production on listed species, NMFS has recommended that an annual production ceiling be established (Schmitten et al. 1995). The NMFS Biological Opinion for 1995-1998 Hatchery Operations in the Columbia River Basin (NMFS 1995) limits annual anadromous fish releases from Columbia River Basin hatcheries to 197.4 million total, of which no more than 20.2 million fish may be produced in the Snake River Basin (for purposes other than Snake River salmon recovery). Artificial propagation for recovery of listed species in the Mid-Columbia Region is exempt from the production cap. Artificial propagation and release of hatchery-reared fish under the Mid-Columbia Hatchery Program (for purposes other than Mid-Columbia River salmon and steelhead recovery) must be consistent with NMFS' Columbia River Basin annual production ceiling. The current basin-wide hatchery production is approximately 160 million. The expected increase in hatchery production of all Plan Species under Phase A of the Mid-Columbia Hatchery Program would be 3.6 million (Table 4), which remains less than the production cap.

1.6.5: Fish marking

Several populations to be propagated in the Mid-Columbia Hatchery Program will be totally marked, or a portion of the propagated fish will be marked. The purpose of the marks will vary, depending upon the particular population. Hatchery fish may be marked for research purposes, for identification of hatchery and natural fish in the broodstock and spawning grounds, or for harvest management objectives. Furthermore, the type of mark to be used will depend on the population and objective. Some marks may not be detectable to fishers. The types of marks to be used will include, but not be limited to: coded-wire tag (CWT; Jefferts et al. 1963) and adipose fin clips, blank-wire tag (BWT), passive induced transponder (PIT) tag, elastomer injection, subcutaneous mylar tag, and neutral genotype mark. Hatchery-produced spring chinook salmon (a high risk species) will probably be totally marked, using CWT and adipose fin clip (this is discussed in Section 3). Initially steelhead will continue to be adipose fin clipped. Low-risk species will be partially or totally marked, depending upon the production group. The degree of risk to these populations from marking is not fully known, but the HWG believes the benefits of marking (research and management capabilities) in some cases exceed the potential detriments (reduced survival) of marking. If the potential reduction in survival from marking is felt to jeopardize a given population, fewer or no fish from that population will be marked, or a less intrusive mark will be considered. For each population, the HWG and the Mid-Columbia Hatchery Coordinating Committee will review the relative risk and benefit of the particular mark strategy proposed. The strategies for marking fish are discussed below:

Fishery contribution and survival

Summer and fall chinook salmon contribute substantially to ocean and lower-river fisheries. Information such as exploitation and harvest rates, escapement, and efficacy of different rearing/release strategies are often required to properly manage these populations. This information will be primarily obtained from CWT recoveries. Ideally, the number of fish to mark in a hatchery production group will be determined from analysis of mark recoveries from similar production groups that were previously released. This analysis will then allow an *a priori* determination of the appropriate number of fish to mark to gather the information. The number of fish to be marked for these purposes must be sufficient in size to meet predetermined statistical power and detection levels (Peterman 1990; Newman and Comstock 1991), and coupled with an appropriate experimental design (Reisenbichler and Hartman 1980). In some smaller production groups, the population size may be less than the number of experimental units required to assess fishery contribution and survival. For these situations, recoveries from multiple-year releases may be aggregated to determine fishery contribution and survival, if the treatment effects are assumed to be constant (De Libero 1986).

Broodstock and spawning ground information

For those species that are at high risk of extinction, supplementation will be used to increase their overall production. Two means to evaluate whether supplementation is meeting its goal of increasing long-term production of the population are:

(1) To compare the demographic characteristics of those fish produced in the hatchery and natural environments (Section 1.9). In general, changes in the structure of a supplemented population are more readily detected in physical and morphometric characters of wild and hatchery fish than in genetic monitoring (Hard 1995); and

(2) To assess the relative contribution of hatchery and natural reared fish in both the hatchery and spawning grounds (Section 2.8). In some situations, it may be prudent to control the relative contribution of wild and hatchery fish in both.

To accomplish these tasks, the hatchery fish must be marked to recognize their origin at the broodstock trap and on the spawning grounds. The mark to be used for these purposes must be recognizable to fishery managers, and must be done for the entire hatchery production. If more than one population is collected or monitored at a common broodstock trap, external marks that are unique to each population may be used.

Terminal area harvest

Some populations may at times have a harvestable surplus in the terminal areas. In these situations, harvest managers recognize the need to ensure (1) adequate escapement to the spawning grounds or hatchery, and (2) that non-targeted populations are not harvested at an excessive level. In general, these factors can be managed through counts of the target population at a point immediately downstream of the harvest area, and allowing harvest only in areas where the target population is isolated. If these conditions cannot be met, it may be prudent to mark the target population to meet management objectives. These marks must be recognizable to fishers.

1.7: Genetic Assessment

1.7.1: The Grand Coulee Fish Maintenance Project

All the salmon and steelhead populations in the Columbia River upstream of Rock Island Dam were impacted by the construction of Grand Coulee Dam in the 1930s. As part of the Grand Coulee Fish Maintenance Project (GCFMP), all salmon and steelhead were trapped at Rock Island Dam during 1939-1944 (Fish and Hanavan 1948). Salmon and steelhead were transferred to the Leavenworth National Fish Hatchery Complex for propagation and release into the Wenatchee and Methow rivers (Chapman et al. 1995a). Adult stream-type chinook salmon were released into a racked area of Nason Creek to spawn naturally. Adult ocean-type chinook salmon were placed into racked areas of the Wenatchee and Entiat

Rivers. At that time, there was no technology available to segregate salmon and steelhead by their stream of origin, resulting in considerable gene flow among all populations (Utter et al. 1995).

Since then, non-native stream-type chinook salmon have not been introduced into the Mid-Columbia Region, except for periodic releases of lower Columbia River spring chinook salmon from selected fish hatcheries (Section 3.2). This has allowed some natural separation of the populations that were mixed in the GCFMP. Now, based upon analysis of allele frequency distributions, natural stream-type chinook salmon within the Mid-Columbia Region appear to be separable from fish produced by the GCFMP hatcheries. A particular separation is between salmon from Leavenworth FH and natural spring chinook salmon in the White and Chiwawa rivers (Utter et al. 1995).

The general biological implication is that stream-type chinook salmon have shown some resilience to genetic perturbations, and a potential to diverge into distinct populations after the effects of the GCFMP. The relocation and confinement of salmonids during the GCFMP largely limited evolutionary divergence to the last 60 years, yet there is some limited evidence that expression of life history adaptation may have occurred within a relatively short time period. Similar results have been seen in chinook salmon introduced to New Zealand (Quinn and Unwin 1993). Based upon this assumption, one strategy to increase population viability would be to reduce hatchery-induced straying and to permit existing populations to develop and adapt within local temporal, ecological, and geographic ranges. Two basic strategies would encourage this process: (1) use local gametes and (2) mark hatchery fish where appropriate to meet management and evaluation objectives.

1.7.2: Genetic distances

The HWG analyzed the level of population separation in the mid-Columbia Region, based upon available genetic data. Substantial electrophoretic data are available for most populations of chinook salmon, yet little data are available for steelhead. The Genetics Unit of WDFW supplied data for both species for this assessment (Appendix E), which were used to identify appropriate levels of population separation for artificial propagation. NMFS Genetics Unit provided data for sockeye salmon. These data are discussed in detail in the individual species' sections.

1.7.3: Assessment and control of effects

Specific genetic effects, both individually and collectively, of the following actions in the Mid-Columbia Hatchery Program are: (1) inter-population genetic effects, and (2) intra-population genetic effects. These impacts, and measures to be taken by the Mid-Columbia Hatchery Program to control them, are discussed below:

(1) Inter-population genetic effects

The straying of non-native hatchery populations causes concerns from the cumulative effects of unidirectional gene flow into the natural populations. This can be described by the following equation: $P=(1-x)^t$, where x is the proportion of foreign genes migrating into a population each generation, t is the number of generations, and P is the proportion of native genes in the final population. Cumulative genetic effects are thus a function of both the intensity and duration of straying. For example, if x=10% per generation, the population after five generations would contain 59% native genes and 41% non-native genes. After ten generations, the composition would be 35% native and 65% non-native. These results apply to a neutral gene. However, selection for local adaptation will reduce the rate at which foreign genes replace native genes.

Hybridization with non-native hatchery fish may lead to outbreeding depression and reductions in fitness for the natural population. Furthermore, straying can lead to a breakdown in population structure if the strays make permanent genetic contributions. The magnitude of the effect on natural species depends on the degree and duration of the genetic interactions, the geographic extent of the populations effected, and the genetic differences between the hatchery fish and natural populations. Examples of possible adverse effects of population transfers of salmonids can be found in Hindar et al. (1991). Local adaptation has been shown to be important for a number of phenotypic and life history traits in Pacific salmon (Taylor 1991).

There is evidence that a number of phenotypic and life history traits in Pacific salmon are the results of local adaptation (Ricker 1972; Taylor 1991). Circumstantial evidence for the importance of local adaptation is provided by Withler (1982), who found that population transfers within the normal range of Pacific salmon have been unsuccessful in producing new anadromous populations, except where the natural colonization has been prevented by an obvious physical barrier. Given these concerns, it is prudent to limit the introgression by non-native hatchery fish into natural populations. All facilities in the Mid-Columbia Hatchery Program will have a co-manager approved plan for management of strays (for example, see Section 3.5.3). This plan may be revised yearly, or when appropriate. Local and/or locally adapted broodstock will be used in the Mid-Columbia Hatchery Program to minimize the phenotypic and life history differences. CWT recoveries will be analyzed to verify stray rates of non-native populations. At most Mid-Columbia hatcheries, CWTs are read and verified prior to fertilization of gametes. Rearing on parent river water, or acclimation to parent river water for several weeks prior to release is done to ensure a strong homing response to the natal stream or hatchery. This should reduce the stray rate to natural populations.

(2) Intra-population genetic effects

Cuenco et al. (1993) identify three possible causes in the loss of genetic fitness within populations: inbreeding depression, genetic drift, and selection. If properly managed, these causes may be effectively controlled in relatively large supplemented populations, but can be more problematic in small high risk populations, primarily spring chinook salmon and steelhead. Several methods to reduce the effects of these factors in the Mid-Columbia Hatchery Program are described below.

The primary means to protect against inbreeding depression is to maintain a large effective population size (N_e; Cuenco et al. 1993), and to minimize *inter se* matings. Waples (1996) suggests that the effective population size for broodstock taken into a hatchery may be as large or larger than would be the case if the fish were allowed to spawn naturally. All broodstock collection and spawning practices in the Mid-Columbia Hatchery Program will have extensive protocols which will mandate practices that increase N_e in the supplemented population. These protocols will include considerations for sex ratio, multiple-pair matings, sperm motility analysis and cryopreservation, wild/natural matings, and other factors pertinent to each population. Inbreeding depression can also occur from inappropriate use of first and second generation hatchery fish in the broodstock, primarily if the supplementation program is successful at returning large numbers of adults (Ryman and Laikre 1991). Hatchery fish will be marked in a manner that will ensure proper identification of their brood year and origin. The ratio and resultant matings of natural and hatchery fish in the broodstock and in the natural environment will be closely managed and monitored. Contingency plans will be established in the broodstock collection protocol for excess hatchery returns. Similar to inbreeding depression, genetic drift is principally a result of a small effective population size. Methods to reduce the risk of genetic drift in the Mid-Columbia Hatchery Program will be similar to those for inbreeding depression.

Hatcheries might inadvertently select for traits that are not adaptive in the natural environment. Possibly hatcheries have the highest likelihood of artificial selection during broodstock collection, yet other factors (such as the rearing environment and feed strategies) may also play a large role. (Waples 1996) describes two strategies to reduce the risk of inadvertent selection during broodstock collection: taking a large sample of the population, and taking a random sample. Both strategies pose risks to the natural population (Bugert 1998) and do not necessarily ensure a reduction in the risk of inadvertent selection (Hard et al. 1992; Waples 1996), yet hatchery managers may seek a balance of these risks (Waples 1996). The Mid-Columbia Hatchery Program will use broodstock collection protocols which mandate these considerations for yearly operations.

Domestication may occur when natural fish are taken into an artificial environment that may impose different selective pressures on them than does the natural environment. Busack and Currens (1995) identified three types of domestication selection: (1) intentional or artificial selection, (2) biased sampling during some phase of culture, and (3) unintentional selection. They recognize that some of these selective processes cannot be eliminated, but can be controlled through three practices:

(1) Use hatchery practices that promote random sampling. This will be accomplished in the Mid-Columbia Hatchery Program by use of rigorous broodstock collection and mating protocols. Bugert (1998) outlines factors to consider in establishing these protocols.

(2) Minimize the time fish are exposed to a hatchery environment, particularly in repetitive use of hatchery fish for broodstock. This can be done through use of natural fish as the predominant component of broodstock. The Mid-Columbia Hatchery Program will use natural chinook salmon and sockeye salmon as the primary broodstock sources. Natural steelhead may not be predominant broodstock source however, because of their small numbers (relative to hatchery fish), but the Mid-Columbia Hatchery Program will use the largest feasible number of natural steelhead in the broodstock.

(3) Make hatchery environments more similar to natural environments. Maynard et al. (1995) reviewed the effects artificial propagation have on the adaptiveness of reared salmonids in the natural environment. Artificial propagation may have the tendency to change the following behavior patterns: reduced use of substrate and woody debris for hiding cover, lack of exercise required to avoid predators, development of surface-orientation for foraging, and loss of cryptic body coloration. Some of these life skills may be developed through alternative fish cultural techniques, which may increase postrelease survival and reduce impacts to natural fish. The potential loss of these life skills through selective genetic pressures from artificial propagation cannot be determined, but the HWG felt the use of "natures" rearing, where practical, may reduce this potential.

1.8: Ecologic Assessment

Artificial propagation can be successfully integrated with the proposed habitat protection and restoration measures under the MCMCP, if they can be done in a manner that is consistent with the supplementation concept (Cuenco et al. 1993) and the basic philosophy for mid-Columbia hatchery management (RICC 1992; WCC 1995). At a minimum, these supplementation programs will incorporate the following strategies: (1) use local (or most appropriate) broodstock, (2) promote natural spawning of hatchery-reared salmon and steelhead, (3) acclimate smolts on surface waters proximal to areas to be seeded, (4) reduce potential for impacts to natural production, and (5) monitor natural populations for indications of beneficial or deleterious effects from the supplementation programs. Using these criteria, carefully considered outplants of native (or otherwise appropriate) anadromous salmonids at selected life stages into off-channel and tributary habitats may substantially increase natural production. However, there is sufficient evidence from preliminary evaluations of supplementation programs (Mendel et al. 1993;

Carmichael and Messmer 1995) for the Mid-Columbia Hatchery Coordinating Committee to develop a cautious, limited strategy for increased hatchery production through the MCMCP. Adaptive management, based upon ongoing evaluations, will be integrated into the operations plan for these programs.

To have an effective strategy for artificial propagation in the Mid-Columbia Region, the HWG identified what populations are appropriate for supplementation, and the level of hatchery production required to encourage increased natural productivity. An assessment of spring chinook salmon and steelhead populations that are not currently self-sustaining is discussed in the respective sections.

A fundamental task in developing a supplementation plan is an assessment of the carrying capacity of the population's habitat, the difference between this value and the present <u>seeding levels</u>, and the level of hatchery production required to seed the habitat. Regardless of the amount of information that is available on a stream, an assessment of carrying capacity is highly speculative (Hall and Knight 1981), and based upon assumptions related to habitat quantity and quality (House 1995), and changes in natural productivity resulting from environmental variability (Ricker 1958; Platts and Nelson 1988). The levels of supplementation, if based upon the concept of carrying capacity, become more important for stream-type salmonids than ocean-type, because of the longer freshwater residence time of the former. Moreover, if the current abundance is well below the estimated <u>production capacity</u>, a phased approach to supplementing these high risk populations is prudent. Simple replacement with hatchery fish to overcome this capacity/seeding level differential may not be fully effective, as several studies have suggested a reduced fitness of hatchery fish in natural environments relative to local natural fish (Reisenbichler and McIntyre 1977; Chilcote et al. 1986). Since full seeding is not simply an additive process of natural fish plus the hatchery releases, considerations will be given to the following supplementation parameters:

(1) the life history stage of the fish to be released,
(2) the quality of the receiving habitat,
(3) the community assemblage and density of fishes in the receiving waters,
(4) the life history type, and level of endemism of the fish to be released,
(5) the anticipated gene flow between the hatchery and natural fish,
(6) the location of the given hatchery release program relative to other hatchery programs, and
(7) productivity of the hatchery fish in the natural environment.
(8) the proportion of natural spawners that are hatchery origin.

Release of healthy fish from the hatcheries is a important consideration in reducing the ecologic impacts of supplementation programs on natural fish. This plan includes only strategies that are presumed to be consistent with NMFS policy for artificial production under the ESA. Hatchery production will meet or exceed the goals established through IHOT (IHOT 1995; Appendix G). As part of the development process for the Mid-Columbia Hatchery Program, the HWG assessed these standards and the hatcheries' capabilities to meet these standards. Based upon analysis of recent-year hatchery performances, they suggested revisions for those facilities involved in the Mid-Columbia Hatchery Program (Appendix G).

<u>1.8.1: Assessment and control of effects</u>

Considerable literature exists which qualitatively describes the various impacts of hatchery practices and production on natural fish populations (Campton et al. 1995; Flagg et al. 1995), but there is little or no information quantifying those impacts. Impact to natural species from artificial propagation programs occur from operation of the hatchery facilities, interactions between hatchery and natural populations in the natural environment, and collection of broodstock. Hatchery actions may adversely affect natural fish through direct mortality (via predation, or other factors), and indirectly through ecological interactions in the natural environment. Specific ecologic effects, both individually and collectively, of the following actions in the Mid-Columbia Hatchery Program are: (1) density dependent effects, (2) operation of hatchery facilities, (3) disease transmission, (4) competition, predation, cannibalism, and residualism, (5) passage impediments, and (6) migration corridor/estuary effects.

(1) Density dependent effects

A fundamental assumption in identifying those populations which could be supplemented is whether the sources of the population's decline are from factors within, or outside the basin of origin (Cuenco et al. 1993). This in turn, allows an assessment of the carrying capacity of the population's habitat, the difference between this value and the present seeding levels, and the level of hatchery production required to seed the habitat. Production capacity depends on system productivity, which fluctuates. Variation in productivity is probably linked to climatic cycles as well as to human activities that have altered the habitat in the last 100 years. The difficulty of estimating a system's capacity to support salmon and steelhead is probably further compounded by cycles of oceanic productivity and other ecological and human factors--effects that may be difficult to isolate from each other. Current production capacity estimates must be based on present conditions and may be lower than historical levels. However, a reasonable estimate of the carrying capacity of the mainstem Columbia River and its estuary is not available, and would be difficult to derive.

The productivity of salmonids in the tributaries to the Mid-Columbia Region has decreased because of loss or alteration of critical spawning and rearing habitats (Bugert et al. 1997a). Moreover, current seeding levels of these streams have decreased because of mainstem passage mortalities. A major objective of the MCMCP is to increase the survival and production of salmon and steelhead in these tributaries. Increasing natural escapement through hatchery releases will increase the seeding levels, but at upper levels there will be diminishing increases in the number of smolts produced (Bjornn and Steward 1990; Fryer and Mundy 1993). Chinook salmon smolt production capacities for the mid-Columbia tributaries (Table 10) were estimated in the NPPC subbasin planning process (WDF et al. 1990 a, b; WDW et al. 1990). These estimates are partly based on the assumption that the highest recorded escapement represents full seeding. The authors state several other assumptions and caveats that should be considered when using these estimates. However, these estimates underwent some peer review and have been widely promulgated. If these capacities are reasonably accurate, they can serve as a starting point for the development of hatchery production strategies. Information gained from ongoing hatchery evaluations under the Mid-Columbia Hatchery Program will assist the Mid-Columbia Hatchery Coordinating Committee in further refining these estimates of production capacity, and the resulting hatchery production objectives.

The NPPC model was not configured to estimate sockeye salmon carrying capacity. Allen and Meekin (1980) estimated an "optimum" adult level of 42,800 spawners for the Wenatchee Watershed. To convert this estimate to smolt capacity, Bugert (1996) calculated the product of an assumed egg-smolt survival rate of 5.5% (Chapman et al. 1995b), a male:female ratio of 1.48:1.00, and an average fecundity of 2,377 (Eltrich et al. 1995). Based upon these assumptions, 1,859,000 sockeye salmon smolts could be produced naturally in the Wenatchee Watershed. The Okanogan Watershed has high variability in escapement and resultant smolt production estimates, combined with the highly eutrophic nature of the lake, results in highly variable production capacity. These factors lead the HWG to use a more conservative approach to estimating the potential for Okanogan sockeye salmon smolt production. The most conservative estimate (4,000,000) was developed by Pratt et al. (1991) and was therefore used by the HWG. The HWG was reluctant to use the NPPC method for estimating steelhead production capacities in these watersheds, primarily because it is a wetted areal based method that is not as appropriate for steelhead as for chinook salmon. The HWG estimated steelhead production capacities through the WDFW Gradient/Area/ Flow Method (GAFM and GAFM2).

The estimated smolt production values were then compared to the current level of salmonid production in these streams (Table 10), estimated by Bugert (1996). Based upon these assumptions, the average seeding level of the streams in the Mid-Columbia Region (excluding the mainstem) is 31.1% of carrying capacity (Table 10). Basin-specific levels are Wenatchee, 42.8% of capacity; Entiat, 31.9%; Methow, 16.1%, and Okanogan 27.1%. These values include natural and hatchery salmonids that spawn and rear naturally in the tributary streams. The estimated seeding levels for chinook salmon are similar to the chinook salmon levels estimated for the Snake River Basin (30% of historic levels or less for most streams; Bevan et al. 1994).

Given the estimated seeding levels, the HWG believes that additional hatchery supplementation will increase production of chinook salmon and sockeye salmon, if framed within a context that reduces interference with natural life history patterns. Supplementation of steelhead should not increase in Phase A of the Mid-Columbia Hatchery Program. Rather, artificial propagation of steelhead should remain at current levels and concentrate on increasing local adaptation and natural productivity.

Table 10. Estimated salmon and steelhead smolt production capacities for the Wenatchee, Entiat, Methow, and Okanogan watersheds, compared to estimated seeding levels for those streams.

Species	Watershed	Smolt production capacity[1]	Recent ten-year seeding levels[2]	Percent of capacity
Summer chinook salmon	Wenatchee	2,960,504	1,112,717	37.6
	Methow	1,470,822	158,251	10.8
	Okanogan	1,435,704	474,560	33.1
	Totals	5,867,030	1,745,528	29.8
Spring chinook salmon	Wenatchee	1,200,000	510,863	42.6
	Entiat	176,000	49,550	28.2
	Methow	826,359	155,734	18.8
	Totals	2,202,359	716,147	32.5
Sockeye salmon	Wenatchee	1,859,000	911,405	49.0
	Okanogan	4,000,000	986,139	24.6
	Totals	5,859,000	1,897,544	32.4
Summer steelhead	Wenatchee	62,167	73,371	118.2
	Entiat	12,739	10,728	84.2
	Methow	58,552	65,586	112.0
	Okanogan	17,570	15,660	89.1
	Totals	151,028	165,345	109.5
	Grand totals	14,079,417	4,374,912	31.1

[1] *Production capacity estimates for chinook salmon were derived from the NPPC habitat carrying capacity model. Estimates for steelhead were derived from the WDFW GAFM2 model (Brown, WDFW pers. comm.). Estimates for sockeye salmon were interpolated from literature reviews.*

[2] *Values reflect 1987-1996 averages. Refer to Bugert (1996) for derivation of estimates for chinook salmon, sockeye salmon and steelhead.*

(2) Operation of hatchery facilities

Potential adverse impacts from the physical operation of hatchery facilities include impacts from water withdrawal and release of hatchery effluent. Water withdrawal for hatcheries located within the spawning and/or rearing areas can diminish stream flow from points of intake to outflow and, if great enough, can impede migration and affect spawning behavior. Appendix G2 lists design criteria for existing acclimation ponds on terminal area streams in the Mid-Columbia Region. These standards will be used for development of new sites for the Mid-Columbia Hatchery Program. Screening of hatchery intakes is critical to ensure that fish are not permanently removed from the stream. During Phase A all new hatchery intakes in the Mid-Columbia Hatchery Program will meet or exceed screening criteria established by WDFW.

All facilities in the proposed Mid-Columbia Hatchery Program discharge hatchery effluent directly into the Columbia River or its tributaries. The existing facilities meet or exceed NPDES requirements, and dilution factors downstream of discharge points will have no affect on habitat quality affecting natural species. Total discharge for the facilities are: Wells FH - 83 cfs; Eastbank FH- 53 cfs; Rocky Reach- 35 cfs; Priest Rapids- 117 cfs. The targeted Columbia River discharge at Priest Rapids Dam during juvenile outmigration is 140 kcfs. At McNary Dam the targeted discharge is 200 kcfs during the outmigration period (NMFS 1994). Hatchery effluent is greatly diluted and will have little if any affect on outmigrating natural species. Appendix H lists methods for monitoring and controlling discharge from Mid-Columbia hatcheries.

(3) *Disease transmission*

Interactions between hatchery fish and natural fish in the natural environment may be a source of pathogen transmission. This impact is probably occurring from headwater spawning and/or rearing areas and throughout the entire migration corridor. As the pathogens responsible for diseases are present in both hatchery and natural populations, there is some uncertainty associated with determining the extent of disease transmission from hatchery fish (Williams and Amend 1976; Hastein and Lindstad 1991). However, hatchery populations are more susceptible to disease pathogens because of the high rearing densities and resultant stress. Under natural conditions, usually low density, most pathogens do not become a source of disease or mortality. When epizootics do occur, they are often triggered by increased population density and unusual changes in the environment (Saunders 1991), and in circumstances when they coexist with the natural fish for extended periods. Consequently, release of large numbers of hatchery fish may cause some loss of natural fish from disease. This effect may be occurring in spawning and/or rearing areas in addition to the entire migration corridor (Sanders et al. 1992).

For all production programs under the Mid-Columbia Hatchery Program, standard fish health monitoring will be conducted (monthly checks of salmon and steelhead) by fish health specialist, with intensified efforts to monitor presence of specific pathogens that are known to occur in the donor populations (specific reactive and proactive strategies for disease control and prevention are outlined in Appendix I). Significant fish mortality to unknown cause(s) will be sampled for histopathological study. Fish health maintenance strategies are described in IHOT (1995). Incidence of viral pathogens in salmon and steelhead broodstock will be determined by sampling fish at spawning in accordance with the Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Populations of particular concern may be sampled at the 100% level and may require segregation of eggs/progeny in early incubation or rearing.

Incidence of *Renibacterium salmoninarum* (Rs, causative agent of bacterial kidney disease) in salmon broodstock will also be determined by sampling fish at spawning. Where appropriate, collected broodstock will be sampled for enzyme-linked immunosorbent assay (ELISA). If required, hatchery staff will segregate eggs/progeny based on levels of Rs antigen, protecting "low/negative" progeny from the potential horizontal transmission of Rs bacteria from "high" progeny. Progeny of any segregation study will also be tested by ELISA; at a minimum each segregation group would be sampled at release. Necropsy-based condition assessments (based on organosomatic indices) will be used to assess condition of hatchery-reared salmon and steelhead smolts at release, and wild salmon and steelhead during outmigration. If needed, condition assessments will be done at other key times during hatchery rearing.

(4) *Competition, predation, cannibalism, and residualism*

Direct competition for food and space between hatchery and natural fish may occur in spawning and/or rearing areas, the migration corridor, and in ocean habitat. These impacts are assumed to be greatest in the spawning and nursery areas and at points of highest fish density (release areas) and to diminish as hatchery smolts disperse (USFWS 1994). Competition continues to occur at some unknown, but probably lower, level as smolts move downstream through the migration corridor (NMFS 1995). Release of large numbers of pre-smolts in a small area is believed to have greater potential for competitive effects because of the extended period of interaction between hatchery fish and natural fish. Release of hatchery smolts that are physiologically ready to migrate is expected to minimize competitive interactions as they should quickly migrate out of the spawning and rearing areas.

Rearing and release strategies are designed to limit the amount of ecological interactions occurring between hatchery and naturally produced fish. Fish are reared to sufficient size such that smoltification occurs within nearly the entire population, which reduces retention time in the streams after release (Bugert et al. 1991). Rearing on parent river water, or acclimation for several weeks to parent river water, also contributes to the smoltification process and reduced retention time in the streams.

Adult hatchery fish that stray to natural spawning areas, rather than return to the hatchery, may also be competing for spawning gravel. However, when spawning populations are at depressed levels, the degree of this impact should be small: there is thought to be a relationship between high spawner density and greater egg loss in the natural environment (Chebanov 1991). Stray hatchery adults may also breed with native fish, potentially altering genetic fitness and influencing their ability to survive in the ecosystem (see Section 1.6).

Hatchery fish may prey upon natural fish. Due to their location, size, and time of emergence, newly emerged chinook salmon fry are likely to be the most vulnerable to predation by hatchery released fish. Their vulnerability is believed to be greatest as they emerge and decreases somewhat as they move into shallow, shoreline areas (USFWS 1994). Emigration out of hatchery release areas and foraging inefficiency of newly released hatchery smolts may minimize the degree of predation on chinook salmon fry (USFWS 1994). Rearing and acclimation pond management strategies in the Mid-Columbia Hatchery Program will be designed to reduce impacts to natural fish.

Predation by hatchery fish on natural-origin smolts is less likely to occur than predation on fry. USFWS (1994) presented information indicating salmonid predators are generally thought to prey on fish approximately 1/3 or less their length. Coho salmon and chinook salmon, after entering the marine environment, generally prey upon fish one-half their length or less and consume, on average, fish that is less than one-fifth their length (Brodeur 1991). Consequently, predation by hatchery fish on natural salmon and steelhead smolts in the migration corridor is believed to be low. In general, predation on natural fish may be reduced by using appropriate fish cultural practices.

Large numbers of hatchery fish may attract predators (both birds and fish) and, consequently contribute indirectly to predation of natural fish. On the other hand, a mass of fish moving through an area may confuse or distract predators and may provide a beneficial effect. Both effects may be occurring to some extent. The presence of large numbers of hatchery fish may also alter the natural species' behavioral patterns, which may influence vulnerability and prey susceptibility (USFWS 1994).

Hatchery-reared salmon and steelhead released into spawning and rearing areas of natural species may fail to emigrate (residualize), and may negatively interact with natural fish. Steelhead residualism has been found to vary greatly, but is thought to average between 5% and 10% of the number of fish released (USFWS 1994). Releasing hatchery steelhead smolts that are prepared to migrate, and timing the release to occur during high flow conditions may minimize impacts to natural fish from steelhead programs.

It is unclear at this time whether or not acclimating and volitionally releasing steelhead smolts can significantly reduce the proportion of residualized steelhead. The incidence of residualism may be reduced by using a combination of acclimation, volitional release strategies, and active pond management whereby remaining steelhead are not released when sampling indicates the majority of remaining fish in ponds are males (Kerwin, WDFW, pers. comm.). This action is taken because preliminary WDFW research indicates that the majority of residualized steelhead are males. Steelhead hatcheries in the Mid-Columbia Hatchery Program will use a combination of these strategies, and will develop a monitoring protocol for reducing steelhead residualization.

(5) Passage impediments

Hatcheries that directly or incidentally take natural salmonids when collecting broodstock typically incorporate a weir or barrier that forces migrating adults to enter a ladder and trap. This effectively blocks their upstream migration, and the trapped salmon and steelhead are counted and either retained for use in the hatchery or released upstream of the weir to spawn naturally. Potential adverse impacts to adults from operation of fish barriers and weirs include delaying upstream migration, rejecting the weir or fishway structure and spawning downstream of the trap (displaced spawning), falling back downstream after passing upstream of the weir, being injured or killed as adults attempt to jump the barrier, and inducing stress by handling. A co-manager approved broodstock collection protocol that is consistent with the overall management strategy for that population will be established for each facility in the Mid-Columbia Hatchery Program. These protocols will identify strategies which provide the highest likelihood of collecting a random sample of the targeted broodstock in a manner that minimizes the risk to non-targeted species, and those targeted species that are not collected.

(6) Migration corridor/ocean

Considerable speculation, but little scientific information, is available concerning the overall effects to natural salmon and steelhead from the combined releases of mid-Columbia hatchery fish in the mid- and lower-Columbia River migration corridor. In a review of literature, Steward and Bjornn (1990) indicated that some biologists consider density-dependent mortality during freshwater migration to be negligible; however, they also cited a steelhead study that indicated there may have been a compensatory effect (Steward and Bjornn 1990). Hatchery and natural populations have similar ecological requirements and can potentially be competitors where critical resources are in short supply (LGMSC 1993). Most of the hatchery production provided in the Mid-Columbia Hatchery Program is compensating for mainstem passage mortalities. The net juvenile migration density downstream from Priest Rapids Dam should be comparable to the baseline run sizes and conditions used to determine MCMCP hatchery compensation levels.

Feeding rates may be an indicator that food is a limiting factor in the migration corridor, which could decrease survival to adulthood. However, it may also be an indicator of poor health or stress even when food is not limited (Dawley et al. 1986). Increased flow, turbidity, gas supersaturation, temperature, and migration rate may also be factors affecting feeding efficiency. Most migrating smolts sampled in Lower Granite Reservoir contained food items and numerous stomachs were full; however, some individuals lacked food (LGMSC 1993). Giorgi (1991) indicated that there is contrasting information on the food habits of yearling chinook salmon at Lower Granite Dam. *Corophium spp*. was the predominant food item in samples collected at Lower Granite Dam in 1987, while guts were generally void of food items in 1989.

Dawley et al. (1986) studied the migrational characteristics of juvenile salmonids entering the Columbia River estuary. In that study, yearling chinook salmon generally had low stomach fullness values from March through April. In May and June, the aggregate fullness values of yearling chinook salmon increased and percentages of non-feeding fish for most groups decreased. However, the consumption values for yearling spring chinook salmon (but not for other species sampled) declined from maximum in May, the peak period of salmonid migration. Relatively low mean fullness and empty stomachs were correlated with close proximity of release to recovery site and/or short migration periods prior to recovery, early March releases, high turbidity, and disease incidence.

Stomach content weights for subyearling and yearling chinook salmon captured at Jones Beach were less than similar sized fish examined at other estuarine and riverine locations. However, some of the comparisons were of fish residing in the estuary versus fish that were actively migrating when sampled at Jones Beach. In a 1980 and 1981 study of the upper Columbia River estuary, Dawley et al. (1986) found that subyearling chinook salmon generally had about half-full stomachs. In a 1992 study involving Bonneville Hatchery fall chinook salmon, Ledgerwood et al. (1993) also found stomachs about half full, even though more hatchery fish are now produced than during the earlier study.

Most mid-Columbia releases of hatchery-reared yearling steelhead and chinook salmon occur in April or May while subyearling hatchery fish are released during June and July. Peak passage of populations over Rock Island Dam is from mid-April to mid-May (FPC 1986). Peak migration of yearling chinook over McNary Dam is from mid- to late-May and peak passage of subyearling chinook mid-July (Johnsen et al. 1989). Migration rates and timing of hatchery fish are associated with flows during spill periods (FPC 1986). We expect little or no overlap in outmigration timing between the releases of mid-Columbia hatchery yearling fish and subyearling summer and fall chinook salmon. There may be some overlap of outmigrating subyearling hatchery releases from mid-Columbia facilities and natural summer and fall chinook salmon.

1.9: Monitoring and Evaluation

Embodied in the Mid-Columbia Hatchery Program, and the concept of supplementation in general, are a broad array of questions concerning natural productivity and population restoration. These questions relate to the conceptual framework of supplementation theory, which in essence assumes that artificial propagation of salmon and steelhead can increase numbers of naturally spawning populations with no impacts to the long-term viability of the target populations, and minimal effects upon non-target species. Several critical uncertainties were identified in the development of the Mid-Columbia Hatchery Program. The first deals with the physical facilities provided to accomplish the goals of the plan. The remaining critical uncertainties concern the potential risk imposed upon the Mid-Columbia salmon and steelhead populations by the supplementation plan and the efficacy of the supplementation plan as a means to restore these populations. These uncertainties are similar in concept to the research needs posed by Cuenco et al.

(1993), who identified two levels of monitoring and evaluation for supplementation projects. The first level is to determine the degree of success of the project, while the second addresses why a particular project is not successful, and what measures can be done to adjust the program.

The following outline provides overall guidance for monitoring and evaluation of the Mid-Columbia Hatchery Program, and means to detect and potentially ameliorate problems encountered in implementation. Species- and population-specific guidelines for evaluation are presented in the appropriate sections.

<u>First critical uncertainty:</u> Are the facilities provided adequate to meet the needs of the Mid-Columbia Hatchery Program in terms of broodstock collection, incubation, rearing, and acclimation?

- ☐ Can the egg to returning adult survival exceed the survival rate of naturally produced fish from that donor population?

- ☐ Can the broodstock collection facilities safely capture sufficient salmon and steelhead in a manner that is consistent with guidelines established in the broodstock collection protocol for that population?

<u>Second critical uncertainty:</u> Does implementation of the Mid-Columbia Hatchery Program conserve the genetic integrity and long-term fitness of naturally spawning populations of salmon and steelhead in the Mid-Columbia Region?

- ☐ What is the reproductive success of hatchery fish in the natural environment?

- ☐ Does the number of progeny spawners in the donor stream exceed those taken from the donor stream as broodstock?

- ☐ Are the allele frequency variations between generations no greater than expected from random genetic drift?

- ☐ Is the effective population size of a donor stream adversely affected by artificial propagation?

<u>Third critical uncertainty:</u> Do salmon and steelhead released from the Mid-Columbia hatcheries interact adversely with natural productivity in the Mid-Columbia Region?

- ☐ Do the returning fish from the Mid-Columbia hatcheries stray excessively and interbreed with other genetically distinct populations?

- ☐ Do the fish released from the acclimation ponds impact naturally-rearing salmon and steelhead in the river?

- ☐ Is natural productivity in the donor population diminished when hatchery-reared salmon and steelhead return to spawn in the natural habitat?

A means to address the critical uncertainties specific to the Mid-Columbia Hatchery Program form the basis for the evaluation of the supplementation plan. The evaluation plan for each aspect of the hatchery program states three specific objectives to obtain the data required to address each critical uncertainty (species-specific evaluations are discussed in the appropriate sections of this document). It is expected that these objectives, and their associated tasks, will form the basis for development of evaluation plans which will include details of the specific hypothesis to be tested, methods, analysis, and report development. The objectives and tasks will be used to determine whether the goals of the Phase A hatchery-based compensation plan are being met. Some tasks may be directed toward all populations--others must be done only on a given stream, to be consistent with the Implementation Strategy (Section 1.4.3). The evaluation plans should be dynamic, with provision for assignment of new tasks directed at solving problems that may become apparent from the initial evaluations.

Objective 1: Determine if the Mid-Columbia Hatchery Program is capable of meeting the Phase A production requirements of the Agreement.

The capability of the facilities to produce the intended number and quality of smolts under the specific design features will be evaluated in this objective. Tasks are directed toward data collection that will lead to solutions to attain the design production capability of the Mid-Columbia hatcheries. For the purposes of this evaluation, the term propagation survival includes the life history from the point of broodstock collection to time of release. This guideline will be the basis for evaluation in Objective 1. Overall survival, which includes propagation survival and survival from release to spawning adult, will be considered as an adjunct to this objective. Survival guidelines (outlined in Table 11 and Appendix G) will be rigorous, relative to other Columbia River hatcheries.

Propagation survival: The Evaluation Plan will determine if the propagation survival (defined in Appendix A) in the hatchery meets or exceeds the guidelines presented in Appendix G. The hatchery and evaluations personnel will keep records of cultural techniques for each life stage. Any problems with operation of the facilities will also be noted. If survival of a particular life stage is below the guideline, then the hatchery operation records could lead to identification and subsequent correction of the problem or studies to determine the cause and remedy.

Table 11. Generalized propagation survival guidelines for salmon and steelhead produced in the Mid-Columbia Hatchery Program. Propagation conditions vary among populations; specific guidelines for populations may differ from the general guidelines below. Specific guidelines for each hatchery are outlined in Appendix G.

Developmental stage	Criterion	Survival (%)
Adults/gametes	Collection to spawning	90
Incubation	Fertilization to ponding	90
Rearing to subyearling	Ponding to transfer	95
Rearing to yearling	Ponding to transfer	85
Acclimation	Transfer to release	90
Propagation (subyearling)	Collection to release	69
Propagation (yearling)	Collection to release	62

Overall survival:. The Evaluation Plan will also assess the fisheries contribution and return survival of salmon and steelhead released from selected Mid-Columbia hatcheries, primarily those that propagate summer and fall chinook salmon. This will ensure that the hatchery complex is successful in replacing those salmonids initially collected for broodstock, and in meeting the long-term objective of sustainable natural production (see Objective 2). Where possible, the Natural Cohort Replacement Rate (Section 1.4.2) of hatchery salmon and steelhead will be measured to determine if it meets or exceeds the replacement rate of natural fish. Survival from release to adult will be measured primarily from CWT recoveries from returns to the donor streams, but information on contribution to various fisheries will be gathered as well. For some hatcheries in the program (primarily those that produce spring chinook salmon and steelhead, all released fish will be marked. Marking is required for assessment of survival rates, for broodstock management, and determination of stray rates.

Broodstock collection: Broodstock will be collected on selected rivers in the Mid-Columbia Region. Ideally, traps should be capable of randomly collecting natural salmon and steelhead throughout the run timing of target populations (see Objective 2). Collection methods must not injure or stress the fish to the point that pre-spawn mortality exceeds the guideline set in Table 3. For some populations, the evaluation plan will determine if the collection methods are capable of obtaining adults which represent the demographics of the donor population, in sufficient numbers to meet desired production levels, and with minimal impact to the collected fish or those allowed to spawn naturally. Traps and weirs should not alter the location or temporal pattern of riverine spawners. Trap operations may affect the movement and spawning activities of naturally-spawning salmon and steelhead. An evaluation of trap design and operations will be required to determine if such impacts do occur, and if so, to develop an appropriate means to mitigate these effects. Fish that die in a trap, or are incidentally killed by a weir during upstream migration will be included in the collection tally.

Objective 2: Determine that actions taken under the Mid-Columbia Hatchery Program conserve the genetic integrity and long-term fitness of naturally spawning populations of salmon and steelhead in the Mid-Columbia Region.

Genetic integrity: The Mid-Columbia Hatchery Program should replace fish incidentally killed at the Mid-Columbia hydroelectric projects without compromising the genetic integrity of existing populations, including both the donor and other populations. The Mid-Columbia Hatchery Program could fail to meet this objective four ways:

1) Excessive straying of hatchery fish into non-target spawning habitat and interbreeding with other populations could alter the gene pool of those populations through introgression of genes or gene complexes not present in those populations.

2) Some individuals collected for broodstock could be from the wrong population, causing introgression of foreign genes into the donor population.

3) Inadvertent selection pressure during artificial propagation could alter the gene pool of the donor populations.

4) Removal of salmon or steelhead for hatchery broodstock could increase genetic drift and reduce genetic diversity by reducing the effective population size of the donor population. This could happen if returning hatchery adults in the next generation fail to replace the natural adults that would have been produced by the broodstock, particularly for donor populations with small numbers of breeders.

The cultural practices established for broodstock selection and mating are critical for maintaining genetic diversity in the donor population. Broodstock trapping should take fish at random from the donor population, including both early and late run fish and different age classes in approximately the proportions that occur in the donor population (Kapuscinski and Miller 1993). Mating procedures should follow a spawning protocol (Seidel 1983, Withler 1988, Leary et al. 1989). A genetic monitoring program is needed to test whether the broodstock and mating procedures are maintaining the genetic character and diversity of the donor populations (Meffe 1986).

Spawning and carcass surveys of both the donor populations and other populations in several watersheds are needed to determine if hatchery salmon and steelhead stray and interbreed with other populations (Scholz et al. 1978, Unwin and Quinn 1993). Surveys in the supplemented streams must be intensive, to determine that sufficient hatchery fish spawn with the donor population to replace the fish taken for broodstock. The evaluation will include information from mark recoveries by other entities outside the Mid-Columbia Region to determine the extent of straying and possible interbreeding of hatchery fish with populations other than the donor.

For some populations, the evaluation plan will monitor selected populations for evidence of introgression of foreign genes, accelerated genetic drift, or loss of genetic variation in the donor populations that could be caused by the hatchery program (Busack 1990). The broodstock should constitute a random sample of the donor populations (Meffe 1986). A monitoring program should test for genetic changes in the donor population that could result from failure of hatchery procedures to maintain the population's genetic integrity.

For some populations, the evaluation plan will contain a monitoring program for electrophoretic analysis of allele frequency variation at selected monomorphic and polymorphic loci. Allele frequency variations between generations should be no greater than expected from natural processes. Polymorphism at a locus previously monomorphic in the donor population could indicate mixture with another population (Utter et al. 1987). A program to monitor asymmetry in bilateral characters will be developed. A progressive increase in average asymmetry over time could indicate a loss of genetic variation (Leary et al. 1984, 1985), or other stressors to the population (Valentine et al. 1972, MacGregor and MacCrimmon 1977).

For some populations, the evaluation plan will determine appropriate numbers (and proportions) of the run-at-large to collect for hatchery broodstock (Ryman and Laikre 1991). Evaluations will focus on determination of effective size (Gall 1987) in some populations. Effective size monitoring will be based upon four components: (1) variation in family sizes among single-pair matings of fish in the hatchery (Nunney 1991), (2) the sex ratio of the donor population, both in the hatchery and in the river (Waples 1990a, b), (3) long-term monitoring of yearly variations in escapement to the donor stream (Staffer 1981, Simon et al. 1986, Ulnar and Hairston 1994), and (4) estimates of effective size derived from electrophoretic data (Pamilo and Varvio-Aho 1980, Waples and Teel 1990).

Long-term fitness: The evaluation plan will conduct spawning and carcass surveys on the spawning areas of selected donor populations in the Mid-Columbia Region to determine replacement ratios and stray rates. Replacement ratios of hatchery-reared salmon will be monitored to determine those levels necessary to maintain long-term viability of the supplemented populations. The number of hatchery-reared progeny that return to spawn naturally in the donor stream should be determined from ongoing evaluations; this information should be used to guide hatchery management. Surveys are required for marked hatchery fish on the spawning areas of salmon and steelhead populations that are not part of the Mid-Columbia Hatchery Program. Surveys of strays to other basins will be coordinated with hatchery evaluations under other compensation plans.

Annual and long-term changes in the spawning distribution of the donor population will be monitored. Hatchery-reared adults should reproduce similarly to natural salmon and steelhead in terms of distribution, timing, and habitat use. The number of progeny spawners in the donor stream should meet or exceed the number of fish established in the Implementation Plan and those that would have been produced had the adults collected for broodstock been allowed to spawn naturally.

For some populations, the evaluation plan will monitor indicators of the fitness of a selected donor population for changes in reproductive success and juvenile production as hatchery fish contribute to the natural spawners. The productivity of the donor population may be affected by the hatchery program, either through genetic effects or because of physical effects resulting from broodstock trapping, environmental or nutritional effects in the hatchery environment, or behavioral differences between natural and hatchery adults (Fleming and Gross 1992). Evaluations will be based upon juvenile production in a donor stream in relation to adult escapement before and after significant hatchery production begins. Several methods might be used to assess juvenile production: (1) annual estimates of parr production on representative index sites in selected habitat types on a natural river environment, (2) annual estimates of smolt yield on a population, and (3) a well-controlled study on a manageable reach of river to measure juvenile production against escapement to that river.

Objective 3: Determine if juvenile salmon and steelhead released from Mid-Columbia hatcheries interact adversely with natural production in the Mid-Columbia Region.

An important goal of the Mid-Columbia Hatchery Program is to reduce potential for adverse interactions between hatchery releases and natural production, such as intra- and interspecific competition for food or habitat, and predation (Riddell and Swain 1991). The potential to meet this goal will be improved if fish released from Mid-Columbia hatcheries are healthy and migrate rapidly.

Some sites in the Mid-Columbia Hatchery Program have been, or will be designed to provide for volitional release of salmon and steelhead from acclimation ponds. The expectation is that the fish will undergo parr/smolt transformation while in the ponds and voluntarily exit through the pond discharge when they are physiologically and behaviorally ready to migrate (Hansen and Jonsson 1985). The optimal release strategy will be determined through observation, operational experience, and, if needed, experimentation with release procedures (Bohlin et al. 1993). Ideally, salmon and steelhead would emigrate from the acclimation pond when physiologically prepared to do so, and this would coincide with good downstream migration conditions (Rottiers and Redell 1993). However, fish may physiologically smolt before migration conditions are favorable. Fish may exit the ponds without showing physical or behavioral signs of smoltification.

An evaluation of fish behavior and migration is needed at the acclimation ponds, in the river at point of release, and at sampling locations in the Columbia River. Observations are needed prior to, during, and after release. Observations should determine: (1) if fish can be reared in a manner that enables them to adapt well to the river environment (Olla and Davis 1989), and (2) if fish emigrating from the acclimation ponds remain near the pond outfall or if they disperse and move downstream (Bilby and Bisson 1987).

Determination of the emigration rate will provide information that may be necessary to optimize the cultural and release strategies for each population. Sampling with PIT tag interrogators, tunnel counters, downstream migrant traps, or other technologies may be needed. Physiological, behavioral, and morphological indicators of parr-smolt transformation may be used to assist in volitional release strategies. Snorkel observations below the pond could determine whether fish migrate and disperse or linger in the immediate area of the release where they could be subject to increased predation or adversely affect naturally produced fish. Retrieval of data from recoveries of marked fish at hydroelectric projects in the Columbia River can provide estimates of travel time and may be used to refine the volitional release strategies. These data could also indicate whether fish from the Mid-Columbia hatcheries migrated through the Columbia River concurrent with naturally-produced fish and during the period when flows and spill for fish protection were in effect.

SECTION 2: SUMMER AND FALL CHINOOK SALMON

2.1: Background

The ocean-type chinook salmon in the mid-Columbia Region is one of the most electrophoretically homogenous populations in the state. The diversity of habitat they use however, is quite high. The HWG set a goal to develop hatchery programs that allow local adaptation to streams in the Mid-Columbia Region. The following approach outlines a method to increase production to meet the MCMCP goal of No Net Impact in a way that encourages local adaptation to the various habitats within the region.

2.1.1: Natural production

Naturally produced ocean-type chinook salmon remain as the primary component of adult returns to the Mid-Columbia Region (Chapman et al. 1994a). Compared to stream-type salmonids in the tributaries, the ocean-type salmonids produced by hatcheries on the mainstem Columbia River are relatively stable and robust. Many of the strategies used by the mainstem hatcheries are nevertheless in need for improvement (Wells subyearlings are an example), but some of their capabilities should be directed toward those tributary populations that require immediate attention. The overall strategy for increasing production on the mainstem will be to establish central propagation facilities for spawning, incubation, and initial rearing, with satellite facilities for acclimation and release. This concept, exemplified by Eastbank FH (RIHC), could be employed to some extent at Wells FH and other hatcheries. A centralized facility has several advantages: increased flexibility in pond and water management, better disease identification and control, increased personnel flexibility, and improved administrative efficiency. Limitations to this reprogramming are the availability of suitable water in late summer (Section 1.5.2). Increased incubation capacity through additional chilled water would assist in this development, by providing more flexibility during the late summer.

2.1.2: Existing hatchery production

Currently, more summer and fall chinook salmon are artificially propagated in the mid-Columbia Region than any other species. Four major hatcheries propagate summer and fall chinook salmon in the region: Wells, Rocky Reach/Turtle Rock, Eastbank, and Priest Rapids fish hatcheries. There is significant interaction among these facilities. Additionally, rearing capacity at Colville Tribal FH and Ringold Springs FH may interact with the hatcheries in the Mid-Columbia Hatchery Program.

Wells FH: Wells FH began operation in 1967 and is located on the west bank of the Wells tailrace. This facility was constructed and is funded by Douglas PUD to mitigate for loss of summer chinook salmon spawning area inundated by Wells Dam. Originally built as a spawning channel, it was reprogrammed to serve as an extended rearing facility in 1977. It now produces both subyearling (484,000 smolts at 20 fpp) and yearling (320,000 smolts at 10 fpp) summer chinook salmon (Appendix F). For the 1976 to 1990 broods, the average survival rates (which includes freshwater fishery contribution and returns to the Mid-Columbia Region) are 0.410% for yearlings and 0.098% for subyearlings (Table 12.). Despite the obvious survival advantage of the yearlings, Wells FH is severely constrained from additional yearling production because of the shortage of late summer rearing water (Section 1.5.2).

Adults are collected throughout the entire run to ensure that the run timing for these populations is maintained. Adult collection is managed throughout the season in response to fish counts at Rocky Reach Dam to ensure adequate escapement above Wells Dam. Adults are spawned at 1:1 male to female spawning ratio. A portion of each day's eggtake is used for on-site hatchery production.

Summer chinook salmon smolts are released directly from the hatchery (subyearlings in June, yearlings in April). About 80% of the broodstock is collected from adults returning to the hatchery; the remaining 20% are collected from the east ladder of Wells Dam. This strategy is used to prevent formation of a distinct hatchery population. Varying numbers of natural summer chinook salmon volunteer into Wells FH on an annual basis and are incorporated into the broodstock. Salmon from the Carlton (Methow River), Similkameen (Okanogan River), and Dryden (Wenatchee River) programs also volunteer into Wells FH, yet they are identified by CWT and placed into their program of origin (Eltrich et al. 1995).

Wells FH operates in a manner that emphasizes the production and release of smolts that are ready to migrate to the ocean and spend a minimum amount of time in the freshwater environment. This should minimize interactions and thus, impacts to natural fish in the migration corridor. Research is done at Wells FH on the time and size at release of hatchery fish to avoid coinciding with the migration of natural species. Wells FH has an aggressive program to develop externally distinguishable marks which can be applied to hatchery fish, to allow the discrimination between them and natural fish.

Rocky Reach FH: Often referred to as the “Annex,” Rocky Reach FH is located on the east bank of the Rocky Reach tailrace. This facility is funded by Chelan PUD, and has an incubation building (which contains 44 vertical incubator stacks) and eight 1,600 ft^3 vinyl raceways. Water supply for the Annex is 6.2 cfs of water seeping around the grout wall at Rocky Reach Dam. This facility works in conjunction with the Turtle Rock Satellite, where the fish undergo final rearing and release.

Table 12. Release-to-adult survival rates of summer and fall chinook salmon reared as subyearlings and yearlings at selected hatcheries in the Mid-Columbia Region. Survival rates are expressed as unweighted means of variable-sized release groups.

Hatchery	Age at release	Release years	Release-to-adult survival rate (%)
Priest Rapids	subyearling	1976 - 1989	0.835
Rocky Reach	yearling	1984 - 1989	1.366
Wells	subyearling	1976 - 1989	0.098
Wells	yearling	1976 - 1989	0.410

Turtle Rock Satellite: Located on Turtle Rock Island 3 km upstream of Rocky Reach Dam, this facility operated as a spawning channel from 1961 to 1969 to compensate for inundated ocean-type chinook salmon spawning habitat by Rocky Reach Dam. It reared and released coho salmon from 1982 to 1992, and currently rears steelhead. It is now used as a rearing and release facility for yearling and subyearling ocean-type chinook salmon (Appendix F). Water supply is 44 cfs of pumped river water to four segments of the channel (11 cfs per channel). Late summer temperatures often reach 20ºC, which precludes rearing of yearlings at this site (Table 8). The 200,000 yearlings (20,000 lbs at 10 fpp) are reared in the eight raceways at Rocky Reach on seepage, then transferred in fall when water temperatures are tolerable (usually in October at 25 fpp), and released from Turtle Rock in April. Egg to smolt survivals at Rocky Reach FH are lower than the performance standards set by IHOT (Peck 1993b; Appendix G). Most of the losses are from coagulated yolk during incubation--primarily a result of warm water. Overall release to adult survival of yearlings has been good, relative to Wells FH (Chapman et al. 1994a; Bugert et al. in prep.). The average release to adult survival of 1984-1989 brood yearlings released from Rocky Reach FH is 1.4% (Table 12).

In 1993, Turtle Rock began annual releases of 1,620,000 subyearling ocean-type chinook salmon (32,400 lbs at 50 fpp). Survival estimates of these fish are not available yet.

Broodstock for the Rocky Reach/Turtle Rock program were initially from Priest Rapids FH, but the source was recently changed to Wells FH volunteers, to prevent mixing of the Upper Columbia summer chinook salmon GDU and the Hanford Reach fall chinook salmon GDU (Table 1). These salmon are considered “fall run” however, to meet production objectives under the CRFMP (Section 1.2.2).

A comprehensive Evaluation/Conservation Plan is being implemented for the Rocky Reach FH yearling and subyearling chinook salmon programs. This plan has been developed to evaluate the program's adequacy in meeting mitigation requirements and to address special conditions described in the Incidental Take Permit for Snake River chinook and sockeye salmon. A major emphasis for evaluations at Rocky Reach FH is to determine rearing strategies that produce smolts that are ready to migrate to the ocean and spend a minimum amount of time in the freshwater environment. A portion of the Rocky Reach subyearling production will be marked with PIT tags to determine migration timing to McNary Dam and any other downstream monitoring sites equipped with PIT tag detectors. The Evaluation Plan calls for development of alternative rearing and release strategies based on results of PIT tag recoveries. Roughly 200,000 of both yearling and subyearling production releases are marked with an adipose fin clip, as well as coded wire tag, for survival evaluation and for discrimination between hatchery fish and natural fish.

Eastbank FH: Built in 1989, the Rock Island Fish Hatchery Complex (RIHC) is one of three components of the mitigation agreement relating to the construction of Rock Island Dam. The mitigation agreement requires that hatchery production be equivalent to the number of naturally produced adults lost due to smolt mortality at the Rock Island Dam. Furthermore, the mitigation agreement requires that the hatchery programs be consistent with maintenance of genetically distinct populations. The central rearing facility for the RIHC, Eastbank FH has an adult holding pond for Wenatchee summer chinook salmon, an incubation room with 315 gpm of chilled water, eight raceways (3,750 ft^3) and five super raceways (22,200 ft^3). The hatchery is located adjacent to Rocky Reach Dam. It is funded by Chelan PUD and operated by WDFW, and has a Section 10 incidental take permit for Snake River chinook and sockeye salmon. Eastbank FH has four wells that supply 53 cfs from an aquifer (Section 1.3.3), with a temperature range of 7.8^o C in May to 13.9^o C in December (Table 8). Eastbank FH provides yearling ocean-type chinook salmon to three acclimation ponds: Dryden (Wenatchee River), Carlton (Methow River), and Similkameen (Okanogan River). The rearing conditions at Eastbank FH (as well as its acclimation ponds) are designed on loading densities recommended by Piper et al. (1982; 6 lb/gpm and 0.75 lb/ft^3) and Banks (1994; 0.125 lb/ft^3/in). Egg-to-smolt survival rates of all populations reared at Eastbank FH exceed the survival standards established in IHOT (Peck 1993a; Appendix G). Eastbank FH began operations in 1989; release-to-adult return rates are not available at this time.

Rearing and acclimation ponds

Fish production at the RIHC is intended to replace fishery losses caused by Rock Island Dam while maintaining genetically distinct populations. To accomplish this goal, hatchery rearing and release procedures include acclimation to parent river water for a minimum of six weeks prior to release. This imprinting is expected to reduce straying of these populations into other areas that contain different populations of fish and reduce interbreeding. The rearing and release strategies are specifically designed to (1) imprint the hatchery fish so that returning fish will spawn with the donor population, and (2) minimize adverse interactions (i.e., competition for food or habitat) of hatchery released and naturally produced smolts. All spring/summer chinook populations are reared as yearlings to increase survival and reduce river residence time. The specific rearing and release strategies for each satellite facility are outlined below.

Satellite facilities associated with Eastbank FH include the Lake Wenatchee net pens, and the Chiwawa (33 cfs), Dryden (16 cfs), Similkameen (21 cfs) and Carlton (15 cfs) rearing ponds. The Chiwawa/Lake Wenatchee complex has a rearing site located on the Chiwawa River approximately one mile upstream of the confluence with the Wenatchee River. The hatchery has two large rearing ponds, a diffuser weir and trap. The facility has two water sources: the Chiwawa River (21 cfs, pumped) or the Wenatchee River (12 cfs, pumped). The latter water source is used only during the winter months when ice forms in the Chiwawa River.

<u>Wenatchee River</u>: The current program is to transfer 900,000 yearling fish from Eastbank FH to Dryden Pond in February. Fish are reared and acclimated on parent river water to a size of approximately 12 fish/pound and allowed to volitionally migrate in April-May. The Dryden rearing facility consists of a large hypolon-lined rearing pond located adjacent to the Wenatchee River near Dryden, Washington. It is used to acclimate Wenatchee summer chinook. The water supply (16 cfs) originates from an irrigation canal that takes water from the Wenatchee River at Dryden Dam. The intake is 1 km upstream of the pond.

<u>Okanogan and Methow rivers</u>: The current program for the Okanogan River is to transfer 600,000 subyearlings from Eastbank FH to the Similkameen Pond in October. These fish are reared and acclimated on parent river water to a size of approximately 10 fish/pound and allowed to volitionally migrate in April-May. The Similkameen rearing facility is located on the Similkameen River near Oroville, Washington. This facility has a large covered rearing pond used for rearing summer chinook salmon. The water supply (21 cfs) is pumped from the Similkameen River. An aeration system was recently installed to supply oxygen to the pond during periods when water flow is shut off due to ice formation or toxic spills in the river. For the Methow River, 425,000 yearling fish are transferred from Eastbank FH to the Carlton (Methow) Pond in February and reared and acclimated to parent river water until release. The fish are volitionally released in April-May at 10 fish/pound. The Carlton facility consists of a large hypolon-lined rearing pond located on the Methow River near Twisp, Washington. This facility is used to acclimate Methow summer chinook. Water (15 cfs) is pumped from the Methow River.

Broodstock collection sites

Broodstock selection and spawning protocols (Appendix J) reflect the need to maintain genetic diversity of these separate populations. The hatchery practices established for broodstock selection and spawning are critical for maintaining the genetic diversity of each unique population. Broodstock trapping is designed to remove representative members from the donor population in a random manner, and in a way to ensure that all segments (age and return timing) of the run are represented.

<u>Wenatchee River</u>: The broodstock selection strategy is to collect predominately natural salmon for broodstock. Insufficient numbers of adults have been collected in some years of operation. Temporary modifications at Dryden Dam in 1992 were largely successful in increasing the number of fish trapped. Permanent modifications were completed in the summer of 1992. When insufficient numbers of broodstock are captured at Dryden Dam, up to 25% of the needed broodstock can be trapped at Tumwater Dam. Unripe females are transported to Eastbank FH for holding and subsequent spawning. The fish are spawned at a 1 male to 1 female ratio; gametes of the least numerous sex are split into subsets and these are crossed with gametes from a different individual of the more numerous sex. Males are also live-spawned when necessary.

Okanogan and Methow rivers: Broodstock collection for the Similkameen and Carlton facilities are currently trapped at the east fishway of Wells Dam. Fish volunteering into Wells FH are used primarily for the Wells program. To prevent inclusion of fall chinook population into the summer chinook gene pool, broodstock collection at both capture sites is curtailed on August 28. The east-ladder-trapped fish are transported to Eastbank FH where they are held until maturity and spawned. Gametes from fish with CWTs are held separately until the origin of the fish is determined. Only summer chinook salmon are used in these programs. A 1:1 mating scheme is employed.

Priest Rapids FH: Located at the base of Priest Rapids Dam, this facility was built in 1963 as compensation for inundated spawning habitat. Funded by Grant PUD and operated by WDFW, it has a Section 10 permit for incidental take of Snake River chinook and sockeye salmon. Originally built as a 1.6 km long spawning channel for fall chinook salmon, it has been converted into six long rearing ponds. The mitigation agreement is for 100,000 lbs of fall chinook salmon production (5,000,000 fish at 50 fpp). In addition, 1,700,000 subyearlings are produced as partial mitigation for John Day Dam. This production group is independent of the Mid-Columbia Hatchery Program. Water is supplied primarily from gravity flow from the Columbia River, but 17.6 cfs of well water is used to control incubation timing. Although not designed as one, Priest Rapids could be considered a supplementation program. Extensive gene flow occurs between the hatchery and the Hanford Reach natural production. Fish are well acclimated to the area, by use of Columbia River water, and the rearing containers mimic the natural river environment in many respects. For the 1976 to 1989 broods, the average release to adult survival (including fishery contribution and escapement) of subyearlings released from Priest Rapids FH is 0.84%, roughly eight times higher than those subyearlings released at Wells FH (Table 12).

Priest Rapids FH provides eyed eggs to various facilities which rear this population. The subyearling chinook salmon program at Rocky Reach FH received 1,800,000 eggs from Priest Rapids up until 1995. They now are received from Wells FH. Efforts have recently been made to control the flow of the Priest Rapids population into the Wells FH and Eastbank FH programs, as it is considered by WDFW to be a separate Genetic Diversity Unit (Marshall et al. 1995).

Adult fall chinook salmon return to the hatchery and adjacent spawning grounds from September through November and are collected as volunteers to the channel. Adults are collected from a trap at the dam ladder but these fish are usually surplus to the hatchery's on station production needs. There is usually a sufficient number of eggs taken to supply other hatcheries. Adults are collected throughout the entire run to ensure that the run timing for these populations is maintained. The spawning protocol mandates the use of a spawning population of at least 500 adults. When spawning fewer than 1 million eggs in a day, the male to female ratio will be 1:1 for all populations. When spawning more than 1 million eggs in a day, the ratio will not be less than 1 male to 3 females. A portion of each day’s eggtake is used for on-site hatchery production.

Rearing and release strategies are designed to limit the amount of ecological interactions occurring between hatchery and naturally produced fish. Fish are reared to sufficient size such that smoltification occurs within nearly the entire population, which will reduce retention in the streams after release. Rearing on parent river water or acclimation for several weeks to parent river water is done to ensure strong homing to the hatchery, thus reducing the stray rate to natural populations. Various release strategies are used to ensure that fish migrate from the hatchery with the least amount of interaction with native populations.

Colville Tribal FH: Located on the north bank of the Columbia River 5 km downstream of Chief Joseph Dam (Figure 7), Colville Tribal FH produces resident fish for losses of anadromous salmonid resources by

Grand Coulee and Chief Joseph dams (BPA 1986). The facilities were built and are operated from BPA funds. The production goal is to annually produce 50,000 pounds of rainbow trout, brook trout *Salvelinus fontinalis,* and cutthroat trout *O. clarki* for release in lakes and streams on the Colville Indian Reservation (Appendix F). The hatchery has 12 incubation stacks, 18 initial rearing troughs, and eight raceways (3,500 ft^3 each). Water supply is about 13.3 cfs, although about 9.5 cfs is required for full production (Table 8).

Ringold Springs FH: Initially built as part of the Columbia River Fisheries Development Program, Ringold Springs FH has been used to rear chinook salmon and summer steelhead. It is currently used in conjunction with Lyons Ferry FH (as part of the LSRCP on the Snake River) to rear 1,100,000 spring chinook salmon (157,140 lbs at 7 fpp). The objective of this production is to provide a fishery to mitigate for lower Columbia River hydropower projects. The preferred broodstock for this program is Hanford fall chinook salmon or mid-Columbia spring chinook salmon, depending upon the current management objective. Cowlitz stock spring chinook is used when the priority broodstock is not available (Peck 1993a). Steelhead are released from Ringold Springs FH (180,000 at 4 - 8 fpp). Broodstock is trapped at Wells Dam and FH, incubated and reared at Lyons Ferry FH, and later transferred to Ringold Springs FH for release in mid-April to mid-May. Skamania stock was also used for production at Ringold Springs FH (Wold 1993), but was discontinued in 1997 (Brown, WDFW pers. comm.).

The facility is 20 km upstream from the Snake River confluence on the west bank of the Columbia River. This facility currently has no capability for incubation because of warm water. Likewise, high water temperatures preclude holding of adult spring chinook salmon. The salmon rearing facilities consist of one large earthen rearing pond (about 3.6 ha surface area) and 14 vinyl raceways, and the steelhead program has one 1.6 ha rearing pond.. The facility has total water rights of 69.2 cfs. Columbia River water is pumped into the rearing pond prior to release (set for early April) to allow some olfactory acclimation.

2.2: Management Assessment

Hillman (1992) analyzed the 1967-1984 brood years to construct a Ricker stock-recruitment relation of summer chinook salmon produced upstream of Wells Dam. He adjusted adult escapement and abundance for system passage survival, and estimated the optimum escapement to be about 2,800 adults. Based upon this analysis and recent escapement data, Chapman et al. (1994a) suggest an escapement management objective of about 3,500 adults. These estimates do not include those chinook salmon that spawn in the mainstem Columbia River upstream of Wells Dam. The average escapement for the period 1985 - 1996 is 4,711 adult and jack summer and fall chinook salmon (as counted at Wells Dam; range: 2,835 - 7,908). The recent trend in escapement is downward for the Methow River, and relatively stable in the Okanogan River (Chapman et al. 1994a). Stock recruitment models are not available for the Wenatchee River, but historical adult returns data (based upon differences in nadirized counts at Rock Island and Rocky Reach dams) indicate an average escapement of 9,553 adults and jacks (range: 5,326 - 13,625) for the years 1985 - 1996 (Table 13). The recent trend in escapement for the Wenatchee River is downward. Historically, summer chinook escapement to the Entiat River has been low. Carie (1995) estimated the 1977 - 1991 average escapement of summer chinook salmon to the Entiat River to be four redds, but he noted that early redd counts were done by plane and likely underestimated escapement. Craig and Suomela (1941) suggested that the Entiat River was historically not extensively used by late-returning chinook salmon.

Historically, Entiat NFH released an average of 239,000 subyearling summer chinook salmon into the Entiat (from 1941 to 1976), Winthrop NFH released an average of 216,000 into the Methow River (from 1941- 1983), and Leavenworth NFH released and average of 50,000 subyearlings into the Wenatchee River (1941 - 1962). The release to adult survival rates of these fish are not known. From 1943 to 1967, five groups of “fall” chinook salmon were released into the Wenatchee River (average: 853,000 subyearlings). These were of separate broodstocks collected on the mainstem Columbia River. Waknitz et al (1995) determined that of the over 200 million ocean-type chinook salmon released since 1941 into the Mid-Columbia River upstream of Priest Rapids Dam, only 6.2 million (about 3%) were non-native.

2.3: Genetic Assessment

The HWG believed that the aggregation of ocean-type chinook salmon into "summer/falls,” with an arbitrary cutoff date between the two does not promote good fish culture or genetic protection. Under the Mid-Columbia Hatchery Program, all ocean-type salmon produced (naturally and artificially) upstream of Rock Island Dam would be managed as *summer* chinook salmon. Fish that spawn in the mainstem Columbia River downstream of Rock Island Dam (principally Priest Rapids FH and the Hanford Reach) are to be considered *fall* chinook salmon. Transfers of fish from Priest Rapids FH to areas upstream of Rock Island Dam will be discouraged.

One or more acclimation/release sites have been developed, or will be developed for summer chinook salmon on the Wenatchee, Entiat, Chelan, Methow, and Okanogan rivers (development of new sites is obviously contingent on procurement of adequate water supplies at biologically appropriate locations). A mainstem stock will be maintained for Wells FH and Rocky Reach FH (Turtle Rock) production, yet gene flow from this stock to others will be acceptable. Efforts will be made to manage these populations separately, yet it is acknowledged that straying among all populations will occur. These populations will be given strong protection against strays from outside the mid-Columbia Region, but efforts to eliminate strays from within the mid-Columbia will not be a priority. Separation and management of these populations would follow three guidelines. Most of these principles would be flexible depending upon with the particular situation (a broodstock protocol for these facilities in Appendix J.1).

1) The primary consideration is to achieve a minimum natural escapement of 2,000 adults and jacks pass Wells Dam, with an emphasis on meeting the 3,500 escapement level. This goal, by far, takes precedence. The broodstock protocol (to be reviewed yearly), would provide the required direction on means to set, and meet, the yearly goal. If the run size is low in a given year, the hatchery programs will be reduced or eliminated to increase escapement. The order of elimination in hatchery programs is: (1) Wells subyearlings, (2) Wells yearlings, (3) the Carlton and Similkameen programs. The trap operations at the east ladder of Wells Dam may be curtailed if needed, to assist in increasing escapement.

(2) The next consideration is to ensure that those salmon intercepted from upstream migration contribute solely to upstream production. For example, volunteers at Wells FH may be used for Methow and Okanogan production, but using salmon trapped at the east ladder for Wells or Rocky Reach should be discouraged, as this places upstream-bound adults significantly downriver. This principle is consistent with the first one; in low escapement years, a preponderance of volunteers can supplement the Eastbank FH broodstock, allowing increased natural escapement.

(3) Marked stray salmon from programs outside the mid-Columbia would be removed from the hatchery broodstocks, when it appears that the percentage of strays from a given program exceeds 5%. This provisional standard is based upon the NMFS Biological Opinion of system wide hatchery operations in the Columbia River, (NMFS 1995a) and will be revised when results from ongoing region-wide analyses of genetic introgression from straying provides more definitive direction.

(4) The long-term strategy would be to transfer production from mainstem facilities (particularly Turtle Rock) to acclimation sites on tributaries (or near mainstem spawning habitat). This action would presumably further encourage local adaptation, release to adult survival, and natural productivity.

Table 13. Average returns of summer and fall chinook salmon to the Mid-Columbia Region, and the number (and percent) taken for broodstock. The returns to the Wenatchee River were estimated by the difference in adult and jack counts between Rock Island and Rocky Reach dams for the period 24 June to 1 September. The returns to Wells Dam includes adult and jack volunteers to Wells FH and those counted in both ladders at the dam for the period 29 June to 15 November.

	Wenatchee River			Wells Dam		
Year	returns	collections	percent	returns	collections	percent
1985	11,654			8,242	1,689	20.5
1986	12,206			6,439	1,118	17.4
1987	12,677			7,670	1,275	16.6
1988	12,914			6,074	1,364	22.4
1989	13,625	336	2.5[a]	6,915	2,147	31.0[a]
1990	10,174	84	0.8	5,212	1,109	21.3
1991	7,723	128	1.7	4,380	1,525	34.8
1992	6,396	331	5.2	4,365	895	20.5
1993	7,913	480	6.1	6,611	1,780	26.9
1994	7,197	417	5.8	10,195	2,287	22.4
1995	6,831	398	5.8	6,469	2,164	33.4
1996	5,326	336	6.3	4,971	1,665	33.5
Averages						
1985 - 1996	9,553			6,295	1,584	25.1
1989 - 1996	8,148	314	4.0	6,462	1,585	25.1

[a] *Broodstock collections for Eastbank FH began in 1989.*

2.4: Ecologic Assessment

2.4.1: Integration with natural production

The primary ocean-type anadromous species in the Mid-Columbia Region is the summer or fall run of chinook salmon. The term "ocean-type" (Healey 1983) refers to the short period in freshwater (less than one year) before migrating to the ocean as subyearlings. Most of their life is spent in the ocean. Spring chinook salmon are considered "stream-type" (spending one or more years in freshwater), and do not commonly show an ocean-type life history that can be verified from scale analysis. Conversely, summer chinook salmon can show extended freshwater rearing to late fall or through winter like "stream-type" fish. Based on limited snorkel observations, summer chinook salmon leave Wenatchee River in summer as expected for ocean-type fish, but some may rear in the mainstem Columbia River for extended periods (DCC 1988). Sneva (WDFW, pers. comm.) estimated that 75% of the natural-reared Wenatchee River summer chinook salmon adults sampled on the spawning grounds in 1995 exhibited a “reservoir reared” yearling outmigration scale pattern. These data were corroborated by scale sampling of summer chinook salmon at Bonneville Dam from 1990 - 1997 (Szerlong, CRITFC, pers. comm). This phenomenon probably occurs on other tributaries to the mid-Columbia River, and suggests that mainstem reservoirs largely influence the success of ocean-type salmonids. Relative to other populations, ocean-type salmonids spend the shortest amount of their life in the tributaries. An important factor that separates this group from others is that juvenile fish have exited the subbasin prior to the lowest flows in fall and are not subject to harsh conditions in winter.

The Mid-Columbia Hatchery Program places increased emphasis on release of ocean-type chinook salmon into the tributaries--areas of significant natural production. Because of this, deleterious ecological effects upon natural fish are of concern. Hatchery strategies that minimize risk to natural populations will be used. These strategies include, but are not limited to, protracted volitional releases, and acclimation on river water. To minimize risks of adult trapping to the natural population, co-manager approved broodstock collection protocol will be required prior to initiation of each year's trap operations.

2.4.2: Rearing/release strategies

In the Columbia River, ocean-type chinook salmon released as yearlings have consistently survived better than those released as subyearlings (Table 12). Ocean-type chinook salmon have been released as small as 5 g during May at age 0, through as large as 80 g during April as yearlings. In general, adult returns of Pacific salmon improve when released at age 1 as opposed to age 0 (Sholes and Hallock 1979; Reisenbichler 1981; Martin and Wertheimer 1989; Bugert et al. 1997b). In the Columbia River, the benefits of rearing juveniles through a yearling stage include (1) improved passage through hydroelectric dams, through coincidental timing of releases with increased flows and spill (Raymond 1988); (2) better fish guidance efficiency of yearlings at the dams because of behavioral and buoyancy changes (Giorgi et al. 1988); (3) decreased susceptibility to predators (Poe et al. 1991; Tabor et al. 1993); and (4) improved swimming performance of larger smolts (Park 1969). The notable exception to this phenomenon is Priest Rapids FH, where fall chinook salmon released as subyearlings return at rates comparable to some hatchery programs in the region that release ocean-type chinook salmon as yearlings. The cause of this higher return rate is not fully understood, but is likely a result of several factors, including (1) the released fish are allowed some natural migration in the Hanford Reach before encountering mainstem dams, (2) the fish encounter only four dams en route to the estuary, compared to 7 - 9 dams for the other hatchery-produced ocean-type chinook salmon, and (3) the fish at Priest Rapids are reared in a semi-natural environment, which may better adapt them to natural rearing and migration conditions.

Based upon the production numbers to achieve Phase A hatchery compensation objectives, the difference in production required between yearling and subyearling ocean-type chinook salmon was on the order of 0.24. In other words, for every 1,000 subyearling summer chinook smolts to be produced for compensation, 240 yearling smolts could be produced in lieu of the subyearlings. This ratio was derived from observed differences in survival between yearling and subyearling releases from Wells FH (Table 12). The HWG assessed the appropriate mix of yearling and subyearling smolts to minimize the risk of this increased hatchery production on the existing natural production. At this time, hatcheries in the Mid-Columbia Region release ocean-type chinook salmon at both ages. Fish from the two rearing strategies encounter different selective processes (such as downstream migration conditions and ocean distribution), yet the demographic characteristics of those salmon released as yearlings have not meaningfully deviated from that of naturally-produced fish. However, the demographic characteristics of the fish reared as yearlings will continued to be monitored, to ensure adaptability of hatchery fish to natural conditions. Demographic characteristics to be monitored will include, but not be limited to release to adult survival, age at return, length at age, sex ratio, and fecundity/length relation.

The current production goals for Wells FH are to release 484,000 subyearlings in June at 20 fpp, and 320,000 yearlings in April at 10 fpp. To meet these goals, an eggtake of 1 million is required. The current production goals for Eastbank FH include 400,000 yearlings for release from Carlton in April and May at 10 fpp, and 576,000 yearlings for release from Similkameen in April at 10 fpp. To meet these goals, an eggtake of 1.2 million is required. To meet the production capacity for yearling chinook salmon, Eastbank must collect 476 salmon (adults and jacks) on the Wenatchee River, and 555 adults and jacks at Wells Dam for the Methow and Okanogan rivers (Table 14). Since this program began in 1989, these collections comprise an average of 4.0% (range: 0.8% to 6.3%) of the Wenatchee and 29.5% (range: 26.0% to 44.0%) Methow/Okanogan adult returns (Table 13). These collections comprise both natural and hatchery origin salmon returning to spawn naturally.

The objective of maximum escapement upstream of Wells Dam must be balanced with the preponderance of volunteers relative to trapped fish. For example, consecutive record low numbers of summer chinook salmon passed Wells Dam in 1991 and 1992, despite relatively strong returns of volunteers to Wells FH. Trapping was curtailed at the dam both years to increase upstream escapement, yet collections of volunteers to the hatchery continued. The result of this action was to take progeny of Wells FH volunteers for production at Eastbank FH. Guidelines for collection, distribution, and spawning of adults collected at Wells Dam and Wells FH are provided in Appendix J.1.

To assess the relative risk of yearling and subyearling hatchery release strategies on natural production, the HWG analyzed four components of these strategies: (1) the effect of broodstock collection on natural escapement levels, (2) the demographic aspects of returning hatchery adults, (3) the potential for genetic changes from the natural population from differing selective processes on yearlings versus subyearlings, and (4) the effects of hatchery releases upon natural juveniles. Those effects are discussed below.

Table 14. Broodstock and eggtake requirements for subyearling and yearling summer and fall chinook salmon produced from existing programs at Wells, Eastbank, and Turtle Rock fish hatcheries.

	Hatchery production goal		Egg take	Broodstock required	
Program	yearling	subyearling	required	volunteers	trapped
Wells Dam[a]					
Wells	320,000	484,000	969,400	441	0
Lake Chelan	0	100,000	117,600	53	0
Eastbank	976,000	0	1,220,000	0	555
Turtle Rock	200,000	1,620,000	2,155,900	980	0
Total	1,496,000	2,204,000	4,462,900	1,474	555
Wenatchee River[b]					
Dryden	864,000	0	1,080,000	0	460

[a] *The Wells Dam values are based on 85% subyearling and 80% yearling egg-to-smolt survival rates, prespawning mortality of 12%, male:female ratio of 1:1, and fecundity of 5,000 eggs/female.*

[b] *The Wenatchee River values are based on 80% yearling egg-to-smolt survival rates, prespawning mortality rate of 10%, male:female ratio of 1:1, jack rate of 3.5%, and fecundity of 5,200 eggs/female.*

Effect of broodstock collection

To meet the interim compensation objective under the Mid-Columbia Hatchery Program, production of summer chinook salmon could increase on the Wenatchee River by 750,000 yearlings, or 3,125,000 subyearlings. This would require 426 adults for the yearling production, or 1,671 adults for the subyearling production (Table 15). To meet the interim compensation objective, production in the Chelan, Methow, Okanogan and mainstem Columbia rivers could increase by 570,000 yearlings, or 2,375,000 subyearlings, requiring either 324 or 1,270 adults as broodstock for the respective strategies (Table 15).

Demographics of adult returns

An extensive CWT database exists on summer and fall chinook salmon released from hatcheries in the Mid-Columbia Region. The HWG analyzed this database to assess the age structure of adults returning to freshwater from subyearling and yearling releases from these hatcheries. Tagged naturally produced fall chinook salmon from the Hanford Reach were assessed as the reference population. With a few yearly exceptions, ocean-type chinook salmon released at age 0 returned to freshwater at an earlier age than those salmon released at age 1 (Table 16). Chinook salmon released from Wells FH and Priest Rapids FH at age 0 showed a higher tendency to return to freshwater after one year or less of marine residency, similar to that pattern shown by naturally-produced Hanford Reach chinook salmon. The highest percentage of subyearling released fish returned as ages 3 and 4. However, summer and fall chinook salmon released as yearlings comprised a larger percentage of the older (ages 5 and 6) returning adults. Hanford Reach fall chinook salmon returned predominantly as ages 4 and 5.

Table 15. Comparison of summer chinook salmon broodstock collection requirements at Wells Dam and the Wenatchee River to meet Phase A hatchery production requirements under the Mid-Columbia Mainstem Conservation Plan. Collection requirements are for subyearling and yearling smolts, and compared against the 1985 - 1996 average returns to Wells Dam and the 1989 - 1996 returns to the Wenatchee River, minus those fish trapped for the existing hatchery programs.

Collection site Production alternative	Anticipated production	Production objective	Broodstock required	Proportion of escapement
Wells Dam				
Subyearling	Chelan River	625,000	334	6.9
	Methow River	500,000	267	5.5
	Chief Joseph	1,250,000	668	13.6
	Totals	*2,375,000*	*1,270*	*26.0*
Yearling	Chelan River	150,000	85	1.7
	Methow River	120,000	68	1.4
	Chief Joseph	300,000	170	3.5
	Totals	*570,000*	*324*	*6.6*
Wenatchee River				
Subyearling		3,125,000	1,671	21.3
Yearling		750,000	426	5.4

Effects of hatchery releases

In the Mid-Columbia Region, subyearling summer and fall chinook salmon are typically released in June at 80 - 100 mm FL; yearlings are released in April/May at 160 - 190 mm FL. It is expected that additional production will have similar target release sizes. At this time, all subyearling chinook salmon are released into the mainstem Columbia River; yearlings are released both in the mainstem and three major tributaries (Wenatchee, Methow, and Okanogan rivers). To increase the potential for natural spawning of the hatchery fish (and resultant gene flow between hatchery and natural fish), the Mid-Columbia Hatchery Program will acclimate a large portion of the additional summer and fall chinook salmon production in the tributaries.

If subyearlings are to be acclimated for a June release in the tributaries, they would be acclimated up to 3 months; yearlings would be acclimated for 1 to 7 months, depending upon the overwinter capability of the acclimation site. Preliminary results of acclimation/release studies at Eastbank FH indicate that yearling summer chinook salmon reared on the natal river water overwinter show a higher release-to-adult survival rate, and better homing to natal areas than salmon reared at the acclimation sites for spring only. Many sites are not suitable to overwinter acclimation however, because of poor winter access. Both age groups would be allowed a volitional release from 3 to 8 weeks in duration. This would lessen the “swamping” effect of large scale releases upon the natural juveniles.

Natural subyearling fry spend a few days to several months in areas from which they emerged. Snorkel observations on the Wenatchee River indicate that ocean-type chinook salmon emergence occurs from mid-February to the end of April, and many move downstream to the mainstem Columbia River during their first year. Most probably depart from tributaries by mid-July. Relatively large yearling hatchery fish recently released from acclimation ponds may interact with recently-emerged natural fish. Their habitat uses would probably differ, because of size-specific habitat and forage needs.

If subyearling releases were used as the additional production under Phase A of the Mid-Columbia Hatchery Program, 3,125,000 smolts would be released into the Wenatchee River (Table 17), which would be 106% of the NPPC estimated smolt production capacity for that stream (Table 11). If yearling releases were used in Phase A, 750,000 smolts would be released, which is 25% of the smolt production capacity. Regardless of which release strategy is used, it would be in addition to the 864,000 yearlings released from Dryden Acclimation Pond (a part of RIHC), which is 29% of the Wenatchee River smolt production capacity. For the Methow River, subyearling and yearling releases would be 34% and 8% of the NPPC estimated summer chinook smolt production capacity (tables 11 and 17), which would be in addition to the 400,000 yearling releases from Carlton Acclimation Pond, which is 27% of the Methow River smolt production capacity.

Selective pressures

In propagating ocean-type chinook salmon to two different ages, the HWG considered the selective processes each strategy employs. Conceivably, a yearling program encourages a shorter duration in outmigration from the Columbia River, whereas the subyearling release strategy encourages rapid growth rates and smolt development. The strongest differences in selection pressures between the two age groups may be in downstream migration. Conditions encountered by age 1 smolts in spring (during the peak of the hydrograph) are markedly different than those met by age 0 smolts at lower summer flows. These higher spring flows would decrease the travel time to the estuary (Raymond 1979; Berggren and Filardo 1993). Because of their larger size, predation risk is lower to age 1 fish (Rieman et al. 1991). Both conditions provide the age 1 salmon with a survival advantage.

When both programs are simultaneously used at a hatchery, it is likely that the gametes from parents that spawn relatively early in the season are used for the subyearling release program at a given hatchery. Conversely, the progeny of later-spawning parents would be placed into the yearling program. This would be done to enable the fish to achieve a desired size: fish that hatch earlier could reach a larger size for a earlier release date, while late-hatching fish could have a retarded growth rate to meet the feeding and growth schedule for a later release.

Conclusion

The HWG believed the least risk strategy for summer and fall chinook salmon for Phase A in the Mid-Columbia Region is to increase emphasis on yearling production, because of their survival advantage. Both strategies (yearling and subyearling releases) have potential for deleterious impacts to the natural production, yet the survival advantages of the yearling releases, combined with its reduced impact to the natural population of broodstock collection, indicate that yearling programs would have less risk.

Table 16. Freshwater age structure of ocean-type chinook salmon returning to the mid-Columbia River, categorized by origin and age of release. Data are based on CWT recoveries in all freshwater sampling areas (traps, fisheries, hatcheries, and spawning grounds).

Origin	Sample	Age at return (percent of total)					
Release age	size	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7
Priest Rapids FH							
Age 0	17,475	8.89	24.22	48.15	18.09	0.64	0.01
Rocky Reach FH							
Age 1	8,242	0.79	17.19	54.53	24.65	2.84	0
Wells FH							
Age 0	762	9.19	26.12	41.99	22.18	0.52	0
Age 1	1,574	0.75	15.38	40.03	38.60	5.11	0.13
Hanford Natural Production							
Age 0	786	9.29	7.00	38.55	44.91	0.25	0

2.5: Risk Assessment

The HWG felt that current and future hatchery production of summer and fall chinook salmon to meet the Phase A MCMCP production objectives may place additional risks on natural populations. This concern was based on several factors: (1) The overall ESU for summer and fall chinook salmon appear to be at low risk of extinction, thereby not requiring extensive hatchery intervention to increase the viability of natural spawners (although some populations in that ESU may be at higher risk than others, and may subsequently warrant supplementation); (2) NMFS (Waknitz et al. 1995) expressed concern over the potential effects of the existing hatchery programs, particularly mainstem releases of "fall" chinook salmon; (3) The HWG felt that additional collections of natural adults for broodstock (particularly for the subyearling release programs) would present a risk to the natural donor populations; (4) The potential for long-term genetic deterioration is accentuated by the high proportion of hatchery fish in the populations, the indefinite nature of the programs, the fact that all populations within the ESU are being supplemented, and the relatively long residence time of yearling-reared fish in the in the hatchery; and (5) The high proportion of hatchery fish on the spawning grounds makes it difficult to accurately assess the health of the natural populations (Section 4.5).

The most certain approach to minimizing these risks would probably be to modify the current and future programs so that hatchery fish are a small fraction of the natural spawners, or are biologically equivalent to natural fish. For various reasons, the first option was seen as unworkable by the majority of the HWG. Therefore, the chosen approach artificial propagation of summer and fall chinook salmon in the Mid-Columbia Region contains the following components: (1) increase hatchery production incrementally over several salmon generations, while closely monitoring the distribution, demographics, and abundance of natural fish in the region, (2) use the criteria established in sections 1.8 and 2.8 as the basis to determine the levels of hatchery production that are consistent with the objective of maintaining a sustainable natural productivity, (3) defer increases in hatchery production if natural productivity appears to be reduced as a result of hatchery production, (4) gradually transfer releases from the mainstem Columbia River to the tributaries, (5) use release strategies that minimize impacts to juvenile natural fish, and (6) provide for overwinter acclimation to these release sites, if possible. If the Mid-Columbia Hatchery Coordinating Committee believes that the current or future production of summer and fall chinook salmon present an unwarranted risk to the natural populations, they may elect to: (1) defer or alter the hatchery production, or (2) develop rearing and release strategies that spatially separate the hatchery fish from natural fish. The basis for these decisions will be from the ongoing evaluation programs. It is important to realize that the power of the monitoring and evaluations programs to detect harmful effects may be low, and that if adverse effects occur it is unlikely that they will be detected quickly enough for adaptive management actions to be successfully applied.

2.6: Production Above Rock Island Dam

Production of summer chinook salmon in the tributaries would increase to meet the Phase A "plug numbers," described in Section 1.4. Some additional production may be considered in later phases of the Mid-Columbia Hatchery Program. Many of the strategies listed use existing facilities, some of which were developed under different compensation programs, such as the Grand Coulee Fish Maintenance Project or the Priest Rapids Project. Production to meet MCMCP objectives at these facilities will be in addition to the ongoing programs. Likewise, these existing facilities will be modified if there is sufficient evidence to indicate that these changes will increase hatchery production and maintain quality of the hatchery-reared fish. Examples of such modifications include chilled incubation water and raceway canopies.

2.6.1: Wenatchee River

Natural production

Ocean-type chinook salmon return to the Wenatchee River primarily in July and August, but may enter the river into early October. They spawn in the mainstem Wenatchee River from the outlet of Lake Wenatchee downstream to its confluence with the Columbia River (87 km). Spawning begins in late September upstream from Leavenworth, and ends in early November in the lower river (Peven and Truscott 1995). Juveniles generally emigrate to the ocean as subyearling fry, leaving the Wenatchee River from one to four months after emerging from the gravel in April. Ocean-type salmonids are most dependent on habitat in the mainstem Wenatchee downstream of Plain. From 1960-1994, the average escapement of ocean-type chinook salmon was 8,826 (based on differences in adult and jack counts at Rock Island and Rocky Reach dams), with a range from 3,394 to 13,625 (Table 13).

Phase A hatchery production

The current production goal of summer chinook salmon in the lower Wenatchee River would be maintained: 864,000 marked yearling smolts (86,400 lbs. at 10 fpp), released from Dryden Acclimation Pond (a part of the Rock Island Hatchery Complex). Wenatchee River broodstock are collected from the run at large at Dryden Dam. To increase production of summer chinook in the upper Wenatchee River, an acclimation pond would be established on the Wenatchee River upstream of Tumwater Canyon (preferably near Plain) to rear 750,000 (75,000 lbs. at 10 fpp) marked yearling smolts for acclimation and release into the upper Wenatchee River (Table 17). The preferred broodstock collection site would be Tumwater Dam. Unmarked (natural) fish would be predominately targeted for broodstock, but a smaller portion of hatchery fish would also be used to prevent mining of the natural run. The specific production strategy would be contingent upon the spring chinook salmon production plan set in the Mid-Columbia Hatchery Program (Section 3). Release of yearling smolts at a smaller size (15 fpp) and reared overwinter on river water should be considered in the production plan. Gene flow between fish released from Dryden and Plain acclimation sites would be acceptable, at all levels.

2.6.2: Entiat River

Natural production

It is suspected that ocean-type chinook salmon was not a dominant life history component of the Entiat River system (Craig and Suomela 1941). Ocean-type chinook salmon return to the Entiat River primarily in July and August, but may enter the river into early October. They spawn in the mainstem Entiat River from the Preston Creek confluence downstream to its confluence with the Columbia River (37 km; Carie 1996). Spawning begins in late September in upstream reaches, peaks on 13-20 October, and ends in early November in the lower river (Peven 1992). Juveniles probably emigrate to the ocean as subyearlings, leaving the Entiat River from one to four months after emerging from the gravel in April.

Based upon redd count expansions, the ocean-type chinook salmon escapement to the watershed averaged 37 for the period 1957-1966, 55 for the period 1967-1976, 9 for the period 1977-1986, and 11 for the period 1987-1991. In 1995, 40 ocean-type chinook salmon redds were observed in the mainstem Entiat River downstream of RK 32. From this count, it was estimated that 110 ocean-type chinook salmon used Entiat River for spawning that year (Carie 1996). No summer chinook salmon spawn in the tributaries of Entiat River, and virtually all ocean-type chinook salmon spawn downstream of Preston Creek confluence. Emergence timing is probably January through April. Juveniles may rear from a few months to a year before migrating downstream.

Phase A hatchery production

Initially, 150,000 (15,000 lbs. at 10 fpp) marked yearling summer chinook salmon would be reared and released at a facility related to Entiat NFH (Table 17). A broodstock collection weir will be built on the Entiat River, with the intent of supplementing naturally producing runs of summer chinook salmon. This trap could be used in conjunction with spring chinook salmon and steelhead collections. Since natural escapement of summer chinook salmon to the Entiat River is low, marked Wenatchee River population (collected at Dryden Dam) would be the primary donor population, augmented by Entiat River collections. Broodstock for this program would eventually shift to the Entiat River, after escapement reaches a level so that donor fish could be collected without deleterious impacts to the natural component.

2.6.3: Chelan River

In Phase A, an acclimation pond will be built on the lower Chelan River to acclimate and release 150,000 (15,000 lbs. at 10 fpp) marked yearling summer chinook salmon. These fish would be derived from marked and unmarked volunteers to Wells FH (volunteers to this Chelan acclimation site would be acceptable broodstock). Adult holding, spawning, egg incubation, and initial rearing would be at Eastbank FH or Wells FH.

2.6.4: Methow River

Natural production

Ocean-type chinook salmon return to the Methow River primarily in July and August, but may enter the river into early October. No summer chinook salmon spawn in the tributaries of the Methow, and virtually all summer chinook salmon spawn downstream of the Chewuch River confluence. The furthest downstream spawning is near the mouth of French Creek, a total of 61 km of spawning habitat. That section consists of four valley bottom types. Spawning begins in late September in the upstream reaches and ends in early November in the lower river (Hillman and Ross 1991). Emergence timing is probably January through April. Juveniles may rear from a few months to a year before migrating downstream. Juveniles generally emigrate to the ocean as subyearling fry, leaving Methow River from one to four months after emerging from the gravel in April. Ocean-type salmonids are most dependent on habitat in the mainstem Methow. From 1967-1991, the average redd deposition of ocean-type chinook salmon to the Methow River was 464 redds (based on adjusted aerial survey estimates), with a range from 93 to 1,055 redds.

Phase A hatchery production

The current production of summer chinook salmon in the Methow River is 400,000 marked yearling smolts (40,000 lbs. at 10 fpp), released from Carlton Acclimation Pond (a part of the Rock Island Hatchery Complex). However, the facility is designed to rear up to 520,000 (52,000 lbs. at 10 fpp). This additional facility capacity was funded by Douglas PUD for reserve production under the Wells Settlement Agreement. Under the Mid-Columbia Hatchery Program, production will increase to this full capacity. Adults are currently collected from the run at large at Wells Dam. Efforts will be made to collect local broodstock on the Methow River, yet the program will rely upon marked and unmarked broodstock intercepted at Wells Dam, until a successful trap is developed on the Methow River. If additional production is required to meet Phase B goals in the Mid-Columbia Hatchery Program, an acclimation pond could be built near the confluence of Gold Creek. Likewise, releases would be shifted from mainstem hatcheries to such an acclimation pond.

2.6.5: Okanogan River

Natural production

In general, the run strength of ocean-type chinook salmon has declined slightly in the Okanogan River over the last 20 years, and has increased slightly in the Similkameen River, its largest tributary, during this period (Chapman et al. 1994a). The 1984 - 1993 average redd counts were 168 redds for the Okanogan River and 300 for the Similkameen River. Adults enter the Okanogan River from July through late September, with the duration of spawning from late September through early November, peaking in mid-October. The spatial distribution of spawners in the watershed is fairly discontinuous. Summer chinook spawn in limited areas between Zosel Dam and the town of Malott, about 103 km. On the Similkameen River, summer chinook spawn from Enloe Dam to Driscoll Island--14 km (Hillman and Ross 1992).

Emergence timing is probably January through April. Juveniles may rear from a few months to a year before migrating downstream. Juveniles generally emigrate to the ocean as subyearling fry, leaving Okanogan River from one to four months after emerging from the gravel in April, although there is evidence that some fish undergo an extended residence period, with protracted downstream movement. Many subyearlings rear in the mid-Columbia impoundments.

Phase A hatchery production

The current production of summer chinook salmon in the Okanogan River is 576,000 marked yearling smolts (57,600 lbs. at 10 fpp; Table 17), released from the Similkameen Acclimation Pond (a part of the Rock Island Hatchery Complex). Adults are collected from the run at large at Wells Dam. Efforts will be made to collect local broodstock on the Okanogan River, yet the program will still rely upon marked and unmarked broodstock intercepted at Wells Dam until a successful trap is developed on the Okanogan River. If additional production is required, an acclimation pond could be built near the confluence of Whitestone Creek. Likewise, releases would be shifted from mainstem hatcheries to such an acclimation pond.

2.6.6: Mainstem Columbia River

In Phase A of the Mid-Columbia Hatchery Program, Wells FH will continue to produce 320,000 yearling (32,000 lbs. at 10 fpp) and 484,000 subyearling (24,200 lbs. at 20 fpp) marked smolts for on-station release. The broodstock for this production are marked and unmarked salmon volunteers to the hatchery. In Phase A of the Mid-Columbia Hatchery Program, Rocky Reach FH will continue to produce 200,000 yearling (20,000 lbs. at 10 fpp) and 1,620,000 subyearling (32,400 lbs. at 50 fpp) marked smolts for on-station release (Table 17). Broodstock will be primarily derived from volunteers to Wells FH, and secondarily from Turtle Rock volunteers. In Phase B, production of 1,620,000 subyearling summer chinook salmon at Rocky Reach FH would be changed to 400,000 marked yearling summer chinook for acclimation and release from a facility (preferably near Whitestone Creek confluence) on the Okanogan River. The 200,000 yearlings from Rocky Reach would be acclimated and released from a facility (preferably near Gold Creek confluence) on the Methow River. Both these changes are contingent upon procurement of adequate land and water rights for these locations.

The part of the summer/fall chinook salmon run that passes Wells Dam after 28 August is currently not being artificially propagated. The HWG felt that this part of the run is genetically similar to those that pass Wells Dam in July and August (or the hatchery volunteers for that matter), but this component should be propagated to ensure that the entire run is equally enhanced. This may protect against selective pressures in artificial propagation. A feasible approach would be to collect some of these fish for propagation and release into the mainstem Columbia River (volunteers to Wells FH could also be used). An acclimation pond would be built at the right bank of the Chief Joseph Dam tailrace, where suitable water is available. This pond would release 300,000 marked yearling smolts (30,000 lbs. at 10 fpp; Table 17).

Two additional management guidelines could be used to increase productivity and local adaptation of summer chinook salmon managed at Wells FH:

1) Segregation of progeny, based upon ELISA screening, is an important consideration. Progeny of females with relatively high values could go into subyearling production. During Phase B, no subyearling production upstream of Rock Island Dam is envisioned. If feasible however, progeny of adults with high ELISA titres would still be placed into a separate program, and may be released as separately marked subyearlings. These releases would follow IHOT and PNFHPC protocols for control of disease transmission.

2) A continuum concept to spawning could be employed at the hatchery. Early spawning volunteers should be used to supplement Eastbank FH broodstock, later spawners can supply Rocky Reach and Chief Joseph, with Wells production somewhere in the middle. This consideration should be balanced with differential incubation timing requirements of yearlings versus subyearlings. Chillers at each facility may be required. A co-manager approved protocol for adult collection, spawning, and distribution of their gametes to these facilities would be required prior to initiation of each year's trap operations.

2.7: Production Below Rock Island Dam

Current production of fall chinook salmon at Priest Rapids FH is 100,000 lbs. of marked and unmarked subyearling smolts (5,000,000 fish at 50 fpp). In addition, 1,700,000 subyearlings are currently produced as partial mitigation for John Day Dam, which is funded from sources other than the MCMCP. Both these production groups will be maintained in Phase A. Under Phase A of the Mid-Columbia Hatchery Program, upriver bright fall chinook salmon releases from Priest Rapids FH would increase to 6 million subyearling smolts (120,000 lbs. at 50 fpp; Table 17), plus the production for John Day mitigation. However, current or future production at Priest Rapids FH for John Day mitigation cannot preclude current or future production capabilities for the Mid-Columbia Hatchery Program. Production for the MCMCP will take priority over production for compensation programs outside the Mid-Columbia Region. The facility would be modified to meet this increased production objective. Modifications could probably include increased incubation and rearing capacities, although an analysis of program needs would be required prior to modifications.

Table 17. Current production objective of summer and fall chinook salmon in the Mid-Columbia Region, and future production under the Mid-Columbia Mainstem Conservation Plan.

Race		Current production objective		Future production objective	
Stock	Facility	Number	pounds	Number	pounds
Summer chinook salmon					
Wenatchee	Dryden	864,000	86,400	864,000	86,400
	Plain	0	0	750,000	75,000
Entiat	Entiat NFH	0	0	150,000	15,000
Wells	Chelan River	0	0	150,000	15,000
Methow	Carlton	400,000	40,000	520,000	52,000
Okanogan	Similkameen	576,000	57,600	576,000	57,600
Wells	Wells FH	320,000	32,000	320,000	32,000
		484,000	24,200	484,000	24,200
Wells	Chief Joseph	0	0	300,000	30,000
Wells	Rocky Reach	200,000	20,000	0a	0
		1,620,000	32,400	0	0
Fall chinook salmon					
URB	Priest Rapids	5,000,000	100,000	6,000,000	120,000
Totals		9,464,000	392,600	10,124,000	507,200

[a] *Current production and releases at the Rocky Reach FH/Turtle Rock facilities will be maintained at current levels for Phase A production. In Phase B, after analyses of the relative risks of yearling and subyearling release strategies to natural production are determined, these facilities may be used for incubation and initial rearing only. Fish may be transferred to acclimation sites for final rearing and release.*

2.8: Monitoring and Evaluation

An extensive monitoring and evaluation program for the existing summer and fall chinook salmon programs has been underway since 1992. These studies are expected to continue, and include any additional summer and fall chinook salmon facilities or production groups developed in the Mid-Columbia Hatchery Program. The basis for the evaluations are to address the critical uncertainties listed in Section 1.4. Specific study objectives for summer and fall chinook salmon are listed below:

Objective 1: Determine if the Mid-Columbia Hatchery Program facilities are capable of meeting the Phase A production objective (Table 17).

Objective 2: Determine whether the survival from release-to-adult of fish from the Mid-Columbia Hatchery Program facilities is sufficient to achieve the Phase A plug number compensation.

Objective 3: Determine if actions taken under the Mid-Columbia Hatchery Program conserve the reproductive success, genetic integrity, and long-term fitness of natural spawning populations of salmon in the Mid-Columbia Region.

Objective 4: Determine whether smolts released from the rearing and acclimation facilities disperse and migrate downstream without impacting the natural population.

Objective 1: Determine if the Mid-Columbia Hatchery Program facilities are capable of meeting the Phase A production objective.

Task 1-1: Determine the prespawning and egg-to-release survivals of fish for each population at various life stages at central rearing and acclimation ponds.

1) Monitor growth, mortality rates, and feed conversion of yearling summer and fall chinook salmon reared at the Mid-Columbia central rearing and acclimation sites.

2) Determine egg-to-fry and fry-to-smolt survival rates for summer and fall chinook salmon.

3) Maintain and compile records of cultural techniques for each life stage, such as: number of times adults handled for observation and inoculation; fish and egg condition at time of spawning; ponding, densities at splits and outplanting, feeding schedule of juveniles, and transport loading densities, tempering, and conditions.

4) Summarize results of tasks for presentation in annual and monthly reports. Make recommendations for improved smolt production at listed facilities. Any problems with operation of the facilities will also be noted.

Task 1-2: Determine if the adult traps are capable of collecting the required number of adults that represent the demographics of the donor population with minimal injuries and stress to the fish.

1) Monitor operation of adult traps in Wenatchee River at Dryden and Tumwater, and at Wells Dam. Additional traps that may be built under the Mid-Columbia Hatchery Program will be monitored. Ensure compliance with established broodstock collection protocols for that station.

2) Monitor timing, duration, composition and magnitude of the runs at adult collection sites.

3) Maintain daily records of trap operation and maintenance, number and condition of fish trapped, and river stage. If low collection rates are a problem, trap data will be compared with fishway operations and flow data.

4) Collect biological information on trap-related mortalities. Determine, if possible, causes of mortality. If possible, use carcasses for stock profile sampling.

5) Summarize results for presentation in annual report. Provide recommendations on means to improve adult trapping, and if needed, refinements to broodstock collection protocols for each population.

Task 1-3: Monitor fish health, specifically as related to cultural practices that can be adapted to prevent fish health problems.

1) Standard hatchery fish health monitoring will be conducted (minimum of monthly checks of salmon and periodic checks of steelhead) by fish health specialist, with intensified efforts to monitor presence of specific pathogens that are known to occur in the donor populations. Significant fish mortality to unknown cause(s) will be sampled for histopathological study.

2) Incidence of viral pathogens in salmon and steelhead broodstock will be determined by sampling fish at spawning in accordance with the Salmonid Disease Control Policy of the Fisheries Co-Managers of Washington State. Populations of particular concern may be sampled at the 100% level and may require segregation of eggs/progeny in early incubation or rearing.

3) Incidence of *Renibacterium salmoninarum* (Rs, causative agent of bacterial kidney disease) in salmon broodstock will also be determined by sampling fish at spawning. Broodstock will be sampled for enzyme-linked immunosorbent assay (ELISA).

4) If required, provide recommendations to hatchery staff on means to segregate eggs/progeny based on levels of Rs antigen, protecting "low/negative" progeny from the potential horizontal transmission of Rs bacteria from "high" progeny. Progeny of any segregation study will also be tested by ELISA; at a minimum each segregation group would be sampled at release.

5) Use ELISA monitoring to help determine efficacy of gallimycin treatments to juveniles.

6) Autopsy-based condition assessments (OSI) will be used to assess hatchery-reared salmon smolts at release. If needed, perform OSI assessments at other key times during hatchery rearing.

7) Provide recommendations on fish cultural practices and satellite stations on monthly basis. Summarize results for presentation in annual report.

Objective 2: Determine whether the release-to-adult survival of fish from the Mid-Columbia Hatchery Program is sufficient to achieve the Phase A production objective (Table 17).

Task 2-1: Estimate the harvest contribution and escapement to the mid-Columbia summer and fall chinook salmon released from Mid-Columbia hatcheries.

1) Compile CWT recovery data from hatchery releases. Provide summary of ocean distribution, contribution, and survival, if such information is available.

2) Recover heads from marked (adipose clipped) returns to mid-Columbia FH facilities during routine spawning operations.

3) Recover heads from marked salmon carcasses during routine stream work.

4) Summarize results for presentation in annual report.

<u>Objective 3</u>: Determine if actions taken under Mid-Columbia Hatchery Program conserve the reproductive success, genetic integrity, and long-term fitness of natural spawning populations of salmon in the Mid-Columbia Region.

<u>Task 3-1</u>: Monitor the hatchery broodstock (and resultant progeny) for evidence of introgression of foreign genes, accelerated genetic drift or loss of genetic variation in the donor populations that could be caused by the hatchery program. Monitor populations in supplemented streams to establish baseline genetic stock identification profiles.

1) Develop a broodstock monitoring program for electrophoretic analysis of allele frequency variation at selected monomorphic and polymorphic loci. Collect tissue samples from each study group for electrophoretic analysis, using methods defined by Coastwide Consortium.

2) Collect tissue samples from summer chinook salmon that enter Wells Dam adult trap, Wells FH, Dryden Dam, Tumwater Dam, and other trap locations developed in the Mid-Columbia Hatchery Program.

3) Prior to release, collect tissue samples of representative juveniles for electrophoretic analysis, using methods defined by Coastwide Consortium. Compare genetic diversity of progeny samples to founder samples.

4) Begin archival of samples for potential DNA analysis in the future.

5) Collect and process adults from all study groups for scale sampling. Sample sizes for other populations will follow standard guidelines set by WDFW for variable escapement.

6) Take lengths of returning adults of all study groups, and determine sex ratios. Determine fecundity of females, and average egg size.

7) Provide results in annual report, or at appropriate time. If necessary, give recommendations for broodstock collections for study groups.

<u>Task 3-2</u>: Determine stray rates of fish released from Mid-Columbia hatcheries into other streams and facilities on the mid-Columbia River.

1) Conduct summer chinook carcass surveys for marked fish on the spawning areas of the Similkameen River, lower Okanogan River, and mainstem Methow River. Coordinate activities with fishery management entities undertaking spawning ground surveys.

2) Determine incidence of marked fish released from one facility in recoveries at other hatcheries in the Mid-Columbia Region. Coordinate activities with hatchery managers.

<u>Task 3-3</u>: Mark each population subjected to ocean fisheries or mainstem Columbia River commercial or tribal fisheries with sufficient CWTs to estimate harvest contribution.

1) Mark (Ad + CWT) and release summer chinook salmon for determination of survival, ocean distribution, contribution to various fisheries, and returns to Columbia River sampling stations.

2) Place an external mark on selected production groups to allow recognition during broodstock collection.

3) Determine the statistical requirements to provide reliable estimates of escapement and harvest contribution. Determine the number of CWTs and other marks needed in relation to the number of recoveries expected.

4) If necessary, begin coordination of large-scale sampling program for CWT recoveries at hydroelectric projects, and on spawning grounds.

Task 3-4: Conduct intensive spawning and carcass surveys for summer chinook on all streams in the Mid-Columbia Region that support ocean-type chinook salmon.

1) Document location and number of naturally spawning spring and summer chinook salmon in these rivers. Conduct redd counts, determine spawner density, and evaluate locations of preferred areas. Determine distribution of redds by river kilometer.

2) Define annual and long-term changes in the spawning distribution of salmon in these rivers.

3) Determine if hatchery-reared adults reproduce effectively in terms of distribution with the naturally produced spawners, timing, and utilization of habitat.

Task 3-5: Begin baseline data collection for determination of Natural Cohort Replacement Rate for selected populations.

1) Enumerate escapement of marked and unmarked salmon to one or more streams. Randomly collect broodstock, as defined in the collection protocol. Estimate total number of spawners in those streams.

2) Use salmon collected for broodstock as random sample of returning population. Collect scales to determine age.

3) Use known age structure, fecundity, and sex ratio of collected adults to estimate egg deposition to those streams. Determine egg retention of marked and unmarked fish by opening carcasses of females during spawning ground surveys. Adjust estimate accordingly.

4) Develop methods for a long-term comparison of total spawner number to number of donor adults taken for broodstock.

5) Summarize results for presentation in annual report. Provide detailed description of methods for long-term analysis of natural cohort replacement ratios.

Objective 4: Determine whether smolts released from the rearing and acclimation facilities disperse and migrate downstream without impacting the natural population.

Task 4-1: Monitor fish behavior and emigration rates from the rearing/ acclimation ponds.

1) Install volitional fish counters (or PIT tag detectors) at outfalls to selected acclimation ponds.

2) Evaluate condition of summer and fall chinook salmon from satellite facilities prior to release. Evaluate smolt quality though OSI analysis, determine sexual precocity, descaling rates, condition factors.

3) Evaluate degree of smoltification at release site. Compare this information to environmental factors (water temperatures, river flows) at time of release.

4) Assess downstream migrants within migration corridor for degree of smoltification. If possible, identify fish to determine stock and release site. Determine trend in parr/smolt transformation in actively migrating smolts given a volitional and forced release.

Task 4-2: Develop a plan to observe fish behavior below and above the discharge at selected rearing/acclimation ponds.

SECTION 3: SPRING CHINOOK SALMON

3.1: Background

The HWG unanimously concluded that hatchery intervention is necessary for the conservation and recovery of spring chinook salmon in the Mid-Columbia Region (Section 1.3). Moreover, the HWG believed that recovery measures through artificial propagation should begin immediately, and all populations in the region should be considered in this plan. However, there was substantial disagreement among HWG participants on the means to categorize and propagate the populations. The salient issues of contention were (1) the scientific rationale for separating mid-Columbia spring chinook salmon into the nine SASSI populations (Table 1), (2) which intervention strategies posed the least risk to the populations while providing the greatest likelihood of recovering those populations, and (3) the feasibility of implementing recovery measures for these discrete segments. There was no debate on the underlying principle--increasing the abundance and productivity of natural populations by encouraging local adaptation--but the degree to which populations should be separated to allow adaptation was questioned.

The HWG investigated several alternatives that could be used in the recovery process, while promoting within- and among-population genetic variability for the nine nominal populations. Some of the HWG members felt that some alternatives either presented an increased risk to the sustainability of the populations, or have low feasibility in implementation. After careful deliberation, the HWG felt the most appropriate plan therefore included a limited use of several strategies to (1) spread the overall risk to the populations and (2) to test the effectiveness of these various strategies for artificial propagation. As stated in sections 1.2 and 1.3, the artificial propagation program for spring chinook salmon has a primary objective: assisting in the species' conservation and recovery. Hatchery production to meet NNI objectives will occur only after the appropriate populations in the Mid-Columbia Region have stabilized at sustainable levels (Section 1.3.3).

"Spreading the risk" includes the use of more than one artificial propagation strategy (Section 3.5.1), collection of broodstock at more than one life stage (Section 3.5.2), incremental changes in production levels (Section 3.5.3), predetermined means to manage stray fish (Section 3.5.4), and two approaches for population separation (Section 3.5.5). All aspects will be monitored (Section 3.7) in a manner that allows comparison of the effectiveness of the alternative strategies. Since hatcheries have been built in the Mid-Columbia Region for spring chinook salmon (Section 3.2), the HWG attempted to design the initial recovery options based upon continued use of these facilities, or to modify them where necessary.

3.2: Management Assessment

The current spring chinook salmon artificial propagation programs in the Mid-Columbia Region can be aggregated into two groups: (1) the Leavenworth NFH Complex, a series of production programs authorized to replace fishery resources lost because of Grand Coulee Dam, and (2) adult-based supplementation programs to increase natural production of spring chinook salmon in the Methow Watershed and Chiwawa River. These supplementation programs were authorized as partial compensation for passage mortalities at Wells and Rock Island dams, respectively. The production and supplementation programs are described below.

3.2.1: Existing production programs

The Leavenworth NFH Complex (Leavenworth, Entiat, and Winthrop hatcheries) began operations in 1939 and uses broodstock originally derived from the run-at-large collected at Rock Island Dam during the GCFMP (Section 1.7.1). The complex initially produced spring chinook salmon through the 1960s.

After a period with no chinook salmon production, the hatcheries reestablished a spring chinook salmon program with broodstock partially provided from lower Columbia River hatcheries. These facilities are required to produce a set number of yearling smolts for fishery contribution under the CRFMP (Section 1.6.3). Production to meet the GCFMP and CRFMP objectives will continue in the Mid-Columbia Hatchery Program, yet some facilities and operations of the Leavenworth NFH complex should be modified to make them compatible with the conservation and recovery efforts in the ESA.

During the early history of the GCFMP the federal hatcheries used anadromous fish captured at Rock Island Dam. Subsequent to those collections, the hatcheries used returns from earlier releases bolstered by the importation of exogenous populations from other Columbia River locations. The early fish cultural efforts had difficulty maintaining runs, often having problems with prespawning mortalities, disease, and use of fingerling releases. The more recent hatchery programs began in the 1970s using Carson stock spring chinook salmon periodically imported from the lower Columbia River. The last direct release of Carson stock into Icicle Creek was in 1986. Leavenworth NFH return rates of Carson/Leavenworth stock have averaged 0.31% since 1979 (Kelly and Hamstreet 1996). Entiat NFH and Winthrop NFH have been less successful and often have difficulty meeting egg requirements. As a result, excess eggs or fish from Leavenworth NFH have been transferred to each of the other stations. This has been infrequent at Entiat NFH but occurred frequently at Winthrop NFH, where release to adult survival for the 1980 to 1989 broods averaged 0.07% (adapted from Chapman et al. 1995b). The last release of Leavenworth spring chinook salmon from Winthrop NFH was in 1994. The practice of transferring spring chinook salmon from Leavenworth NFH to Winthrop NFH has been discontinued to encourage local adaptation of naturally spawning Methow River populations.

Efforts have been underway to improve the success of these facilities (Shelldrake 1993); some of these improvements could assist in making a transition toward meeting the objectives of a conservation program. The present broodstock collection strategy has three levels of priority if egg needs have not been met from returning hatchery adults: (1) fish native to the river the hatchery is on, (2) upper mid-Columbia stock, and (3) Carson stock in years of poor escapement (Shelldrake 1993).

Leavenworth NFH:

Located on Icicle Creek, Leavenworth NFH. It has 108 starter tanks, 72 troughs, 40 small and 22 large Foster-Lucas ponds (which are not currently used), 45 raceways, and 2 adult holding ponds. Water sources include 7 wells, Icicle Creek, and Snow and Nada lakes located in the Alpine Lakes Wilderness. Broodstock comes from adults returning to the hatchery. Fish are spawned at 1:1 male:female ratio, along with one back up male/female. The progeny are reared for 20 months and force released in mid-April. Production is 1,625,000 yearling smolts (15 - 18 fpp) released directly from the hatchery into Icicle Creek (Appendix F).

Entiat NFH:

Located at RK 10 on the Entiat River, Entiat NFH operates as a satellite of Leavenworth NFH. Rearing facilities include 43 starter tanks, 30 raceways, and 2 adult holding ponds. These holding ponds are used to overwinter smolts for release in spring. Water sources include Entiat River, Packwood Spring, and 6 wells (Table 8). Broodstock comes from adults voluntarily returning to the hatchery. Fish are spawned at 1:1 male:female ratio. The production objective is 400,000 yearling and 400,000 subyearling smolts, released directly from the facility in early April at 15 - 18 fpp, and in June at 70 fpp, respectively (Appendix F). Acceptable stocks for production are Entiat River or Leavenworth stock, in that order of preference (Shelldrake 1993).

In the initial years after Grand Coulee Dam was built, little effort was made to reestablish wild spring chinook salmon runs in the Entiat River. Entiat NFH released approximately one million subyearling and less than 50,000 yearling spring chinook salmon from 1942 to 1944. These fish were offspring of the upriver populations collected at Rock Island Dam (Mullan 1987). No spring chinook salmon were released from Entiat NFH from 1945 to 1975 (Carie 1996). Despite this, a wild spring chinook salmon run was observed as early as 1956, spawning in the area above Stormy Creek confluence (French and Wahle 1965). Entiat NFH resumed spring chinook production in 1974, with releases beginning 1976. Sources of supplemental eggs have included Cowlitz River (1974), Carson NFH (1975-1982), Little White Salmon NFH (1976, 1978, 1979, 1981), Leavenworth NFH (1979-1981, 1994), and Winthrop NFH (1988). Returning adults that voluntarily entered the hatchery were the primary broodstock in 1980 and from 1982 to present (Carie 1996). The average return rate from the 1979 - 1989 broods was 0.085% (Kelly and Hamstreet 1996). Pastor (1997) estimated the survival rates of the 1988, 1989, and 1990 broods to be 0.102%, 0.050%, and 0.004%, respectively.

Winthrop NFH:

Located at RK 72 on the Methow River, Winthrop NFH operates as a satellite of Leavenworth NFH. Rearing facilities include 42 vertical-flow incubators, 34 starter tanks, 46 raceways, 16 Foster-Lucas ponds, and two partially-built adult holding ponds. Water sources include 2 wells, the Methow River, and spring water (Table 8).

The current and long-term production objective is 800,000 yearling smolts (53,333 lbs. at 15 fpp) released directly from the facility into the Methow River in April (Appendix F). For the brood years 1979 to 1990, the number of adult returns per adult spawned in the previous generation ranged from 0.005 for the 1990 brood to 1.5 for the 1982 brood, although egg transfers from Leavenworth NFH may confound analysis of some brood year returns (Cates, USFWS, pers. comm.). Winthrop NFH has released an average of 962,982 yearling smolts for the years 1981 to 1993 (range: 624,771 - 1,167,625); sizes at release has ranged from 20 fpp to 13 fpp. The average release-to-adult survival rate of these fish is 0.052% (range: 0.0005% - 0.165%; Cates, USFWS, pers. comm.). Given existing conditions at Winthrop NFH, release-to-adult survival is probably higher when fewer than 800,000 yearling smolts are produced (Cates, USFWS, pers. comm); optimum performance of the hatchery is at some lower production objective, although more information is needed to determine this value. In the interim, Winthrop NFH will produce fish at levels consistent with Methow FH. Initially, Winthrop NFH will have an interim production objective of 600,000 yearling smolts, requiring 362 adults for broodstock (based on a fecundity of 4,400, sex ratio of 1:1, and a propagation survival of 82.6%; Appendix F). The production objective will be adjusted to 800,000 as Winthrop NFH is modified.

The HWG felt that it is inefficient, if not counterproductive, to have two adjacent hatcheries (Winthrop and Methow) produce spring chinook salmon under different management strategies. One resolution of this conflict would be to integrate the two facilities into a unified approach. To their mutual benefit, the interaction between the two facilities increased in 1996, most notably because of the initiative to collect broodstock at Wells Dam instead of at the terminal sites (Section 3.2.2). There still are several administrative and programmatic barriers to this integration. However, there are genetic risks associated with integrating the two programs. Some HWG members felt that supplementation with the Winthrop NFH population (with some out of ESU ancestry) could be deleterious to the native natural Methow populations. In addition, the HWG felt that there is an inherent difficulty in assessing the success of a combined production/supplementation program. Another alternative the HWG considered is to maintain the production and supplementation programs separately. This would allow managers to both control and assess their impacts to natural populations. In practice, it would be difficult to maintain adequate separation between the two programs, particularly when the two hatcheries are in close proximity to each other.

3.2.2: Existing supplementation programs

The two adult-based supplementation programs began recently in the Mid-Columbia Region (Chiwawa FH started in 1989 and Methow FH started in 1992), so little information is available on the performance of these programs. Both have had difficulties in collecting adults for broodstock however (Bugert 1996), and have consequently produced less than program capacity.

Methow FH:

Methow FH is located at RK 74 on the Methow River. The facility is funded by Douglas County PUD to partially mitigate for fishery impacts caused by Wells Dam. The hatchery has satellite facilities located on the Twisp and Chewuch rivers; these sites have adult traps and juvenile acclimation ponds. Rearing units at the central facility consist of 24 start tanks, 15 raceways, and an acclimation pond. Three of the raceways also serve as adult holding ponds. The hatchery uses both well water and river water (Table 8). The central hatchery is used for adult holding, incubation, and rearing of spring chinook salmon. Fish are released at both the central and off-station acclimation ponds. Adult fish that are collected from the Twisp and Chewuch Rivers are transported to Methow FH where they are held and spawned. Following egg incubation and early rearing, juvenile fish are transported to acclimation ponds at the parent river for final rearing and release. A broodstock selection protocol is developed each year. All fish are spawned at 1:1 male to female ratio. The fish are reared to 15 fpp, acclimated to their natal river water for minimum of six weeks, and volitionally released in April-May. Although returns are incomplete, preliminary estimates of survival from release to adult are 0.08% for the 1992 brood and 0.01% to 0.07% for the 1993 brood (both estimates are through age 4 returns; Brown, WDFW, pers. comm.).

Based on an average fecundity of 4,400, an equal sex ratio, and a propagation survival of 74.7% (Appendix G), the long-term Methow FH production objective requires 449 adult brood to produce 738,000 yearlings smolts (49,200 lbs. at 15 fpp). At this time however, Methow FH is capable of achieving a propagation survival of approximately 90% (Appendix G) and safely rearing 550,000 yearling smolts (36,667 lbs. at 15 fpp) when sequential brood years are propagated. When Methow FH was constructed, the rearing density design criteria used for all life stages was 0.75 pounds per cubic foot of rearing container volume, regardless of fish size. Fry have higher metabolic demands than larger fish (Banks 1994). To account for this difference, a more appropriate strategy is to rear fry within a density index (DI) based on pounds of fish per cubic foot of rearing space divided by the length of the fish (in inches). The recommended maximum DI for chinook salmon is 0.125 lbs./cu. ft./inch. Using this index, a fish 6 inches in length or longer would meet the current design criterion.

The major limitation at Methow FH is a deficient number of start tanks (24) and insufficient raceways for the planned program size. The three rearing/acclimation ponds are slightly more than adequate for the full program of 738,000 yearling smolts. Several rearing options are being explored; this deficiency may be addressed in the Mid-Columbia Hatchery Program. Until the initial rearing space is expanded, the interim objective for Methow FH should be to collect 306 or fewer adults for a production objective of 550,000 yearling smolts (36,667 lbs. at 15 fpp).

The terminal area traps on the Twisp and Chewuch river have had variable success in collecting broodstock. Trap efficiency at the Twisp weir has ranged from 15 to 21%, and 8 to 60% on the Fulton (Chewuch) trap. The Foghorn trap was modified in 1995 to collect fish on the mainstem Methow River (upstream of the Twisp and Chewuch confluences); its trap efficacy has not been evaluated. The Methow FH outfall channel (Foghorn ditch) attracts salmon volunteers, yet most of these volunteers are hatchery origin.

In 1993, some fishery managers proposed abandoning the terminal traps and collecting broodstock at Wells Dam (on the mainstem Columbia River; Figure 1). The Wells Dam strategy could meet all criteria for broodstock collection except one: capability to target the three populations individually. After four years of debate, managers agreed that Wells Dam should be tested in 1996 as the trap location. This decision was prompted by two factors. First, record-low returns in 1995, and predicted low returns in 1996, led managers to assume that the risk of extinction to these populations surpassed the risk of reduced within-population genetic integrity. Placing the fish in the hatchery would presumably improve their survival and therefore, increase their likelihood for recovery. Second, the technology to separate populations by analysis of rare earth elements in scales of individual fish showed sufficient promise to attempt this technique. In 1996, 464 fish (126 natural, 338 hatchery) were collected for broodstock at Wells Dam. Managers segregated most natural fish into their perceived populations of origin. For salmon with unknown origin, they accepted a 0.60 probability of correctly classifying the river of origin for these fish (Brown, WDFW, pers. comm.). Managers could separate hatchery fish into the appropriate populations during spawning by analyzing their CWTs.

Chiwawa FH:

An adult collection weir and two rearing/acclimation ponds are located together at RK 2 on the Chiwawa River. Production capacity is 672,000 yearling smolts, yet this facility has operated at roughly 10% of capacity since it began operations in 1989. Poor escapement and logistical difficulties in broodstock collection have hindered full production at this facility (Bugert 1996). The design program is to trap adults at the weir for transport to Eastbank FH where they are held and spawned. Up to 700,000 subyearlings are transferred from Eastbank FH to the Chiwawa Pond in September. The juveniles are reared and acclimated on river water to a size of 12 fpp and allowed to volitionally migrate in April-May as yearling smolts. Although returns are incomplete, preliminary estimates of survival from release to adult are 0.443% for the 1989 brood, 0.036% for the 1990 brood, 0.025% for the 1991 brood, and 0.007% for the 1992 brood (Brown, WDFW, pers. comm.).

When the supplementation program was designed, managers required that a trap be built on the lower Chiwawa River, to exclude the collection of the other populations. The hatchery's production capacity required 400 adults be collected from the run at large. To ensure random collection of the total population, the entire run had to be intercepted, yet only a small portion would be retained. As is typical of stream-type chinook salmon in the region, adults enter the Chiwawa River from May through the onset of spawning (primarily in September). Mean flows in the Chiwawa River during that period range from 7 m^3/sec to 31 m^3/sec; the trap must be equally effective at both extremes. If the weir is operating as designed, no more than one-third of the trapped adults are kept for broodstock and the remaining fish are allowed to pass upstream. Protocols for each year's adult collection are developed in the year of return, and use the predicted run strength as the primary factor in their development. The trap used at Chiwawa serves three functions: (1) it collects all sizes and ages of returning adults, (2) it allows for segregation of hatchery or natural origin fish, and (3) when not collecting broodstock it must pass fish upstream with minimal delay. The original broodstock collection strategy at Chiwawa was to retain no more than 30% of the naturally produced adults returning to the river, and pass all hatchery-origin fish upstream. Since 1995, hatchery fish have also been collected for broodstock. The mating guidelines include splitting of gametes of each sex into subsets for cross matings, splitting of eggs into sufficient numbers of subsets to accommodate 1:1 matings with males (particularly if there are more males), live spawning of individual males, and cryopreserve milt for use in successive years.

3.3: Genetic Assessment

At this time, it appears that NMFS will propose that spring chinook salmon upstream of the Yakima River confluence be designated as one ESU. However, nine discrete populations of spring chinook salmon in the Mid-Columbia Region have been recognized in the SASSI process (WDF et al. 1993a; Table 1). Two populations in the Methow Watershed (the Methow and Lost populations) were combined in the development of the MSP program, resulting in three distinct populations that have been managed in that watershed (Methow, Chewuch, and Twisp). The three Methow Watershed populations have been sampled for electrophoretic analysis intermittently since 1992. Significant differences in allele frequency profile has been detected by G-test (Sokol and Rohlf 1981) between the samples collected from the Twisp, Chewuch, and Methow rivers (Busack, WDFW, pers. comm.) so the three populations have been managed as genetically distinct stocks. However, the genetic collections all contained fish that were identifiable through scale patterns as being of hatchery origin. These fish presumably originated from Winthrop NFH, but possibly from other areas as well. The unmarked hatchery fish comprised a small percentage of fish collected from the Twisp and Chewuch, but a majority of the fish collected from the Methow. Thus it seems likely that the Methow population has been much more heavily influenced by hatchery releases than the Twisp and Chewuch populations.

Utter (1993) and Marshall and Young (1994) found the spring chinook salmon reared at Winthrop NFH to be electrophoretically similar to those at Leavenworth NFH. The current programs for Leavenworth, Entiat, and Winthrop NFHs were founded on out-of-ESU populations. On an intermittent basis, Winthrop and Entiat NFHs have propagated out-of- ESU populations to augment their current program over the last two decades. The last release of non-native spring chinook salmon by Winthrop NFH into the Methow River was 77,000 yearlings, 1992 brood year, from Leavenworth NFH. Some HWG members expressed concern over the potential genetic effects of continued use of the existing Winthrop stock in the recovery program for Methow River spring chinook salmon.

The SASSI process identified the Entiat population as distinct (Table 1), although there is a paucity of information on the genetic and demographic structure of this population (Appendix E2). Some HWG members assumed that maintenance of this population separate from the others was the least risk approach to their recovery. Entiat NFH has predominantly used a broodstock comprised of voluntary returns to the hatchery from Entiat River adults (comprised of both hatchery and natural salmon), augmented by Leavenworth NFH gametes in years of poor returns. WDFW collected 69 electrophoretic samples in 1994, but these samples have not been analyzed; WDFW resumed these collections in 1997. At this time, too few samples of naturally spawning adults on the Entiat River have been available to determine the genetic relation of natural spawners to those at Entiat NFH. Some genetic data on the Entiat population are available (Hershberger et al. 1987), but these data are quite dated. The locus coverage on these collections is incomplete compared to current standards (Busack, WDFW, pers. comm.); the HWG felt these data do not contribute substantially to the analyses. The Entiat River has been surveyed for marked spring chinook salmon carcasses since 1990; no CWTs have been recovered in those years except 1997 when four marked fish were recovered (one from Methow FH, one from IDFG Powell Ponds, one from IDFG McCall FH, and one no tag; Blakley, WDFW, pers. comm.).

Spring chinook salmon in the Wenatchee Watershed have been extensively sampled for electrophoresis since 1987, providing good genetic background of some populations. Four populations were recognized in the SASSI process for the Wenatchee Watershed (Chiwawa, White, Nason, and Little Wenatchee; Table 1). Some HWG members believed that these separations should remain in the recovery program and some members asserted that the Little Wenatchee population was functionally extinct. WDFW attempted to determine the genetic population structure of the Little Wenatchee population from 1990 to 1995, but were unable to collect enough samples to warrant analysis.

In a separate process, WDFW analyzed the genetic relation of selected wild and hatchery spring chinook salmon populations in the Mid-Columbia Region, based upon available electrophoretic data (the genetic distances of the sampled populations in the region are shown in a dendrogram in Appendix E1). The HWG deliberated on the use of these data for development of the hatchery intervention plan. Some HWG members asserted that such studies of biochemical variation do not allow any interpretation of the adaptive significance of genetic differences among local breeding populations, because we do not completely understand the relation between biochemically detected genetic variation and phenotypic variation. The HWG used these results in conjunction with available historic, demographic, and ecologic information to revise this grouping for development of the hatchery intervention plan (the revised dendrogram that incorporates these considerations is in Appendix E2). The HWG made assumptions about some naturally produced groups that have too few samples to have a clear understanding of their relation to hatchery-origin fish, or to each other. Their assessment was then distributed to salmon geneticists and ecologists for review, and then used in the deliberations on the least-risk approach for hatchery intervention.

3.4: Ecologic Assessment

The HWG assumed the entire run of spring chinook salmon in the Mid-Columbia Region employs a stream-type life history strategy (Healey 1983), although many populations appear to move downstream from low-order tributaries into larger rivers for later rearing (Hubble and Sexauer 1994; Petersen et al. 1995). This strategy may have been historically more prevalent than now (Bugert et al. 1997a). Spawning in the small order tributaries may have promoted separation and local adaptation of populations, yet some progenies of these separated spawners probably rear and overwinter together in lower reaches of the watersheds. Many of the upper watershed streams differ hydrologically and limnologically from one another. These differences have likely played a role in the distribution and abundance of spring chinook salmon in the Mid-Columbia Region. Also, the physical differences in the watersheds affect the feasibility of various approaches for hatchery intervention. The HWG considered these factors in developing the appropriate means to categorize the populations, and the means to propagate them.

Wenatchee Watershed

Historically and presently, the abundance of spring chinook salmon is higher in the Wenatchee Watershed than in the Entiat or Methow rivers. This difference probably is because (1) the Wenatchee Watershed has the highest base flow and surface area of streams accessible to anadromous salmonids, and (2) winter water temperatures and late summer flows are moderated by Lake Wenatchee, providing more suitable rearing conditions (Mullan et al. 1992). More than 80% of the natural production of spring chinook salmon in the Wenatchee River is in the upper watershed, mostly in the Chiwawa River, which is a relatively large, pristine, glacial-fed tributary. Four streams are in the upper watershed (Chiwawa River, Nason Creek, Little Wenatchee River, and White River; Figure 2) and support nominal populations of spring chinook salmon. The White River population, in particular, is separable from the other three based on allele frequency distributions (Utter et al. 1995). Although not documented, it is highly likely that juveniles from the White and Little Wenatchee rivers overwinter in Lake Wenatchee.

Leavenworth NFH releases spring chinook salmon directly into Icicle Creek, which is geographically distant from the upper four tributaries. These hatchery salmon appear to have strong homing fidelity to Icicle Creek, where they are imprinted. Moreover, poor passage conditions in Tumwater Canyon during high flows probably discourage Leavenworth NFH-origin salmon from migrating past Icicle Creek and spawning with these upper populations. There is little evidence that current operations by Leavenworth NFH will adversely affect the recovery of the four upper Wenatchee Watershed populations. However, the HWG believed that Leavenworth NFH could be modified, and work in conjunction with the Mid-Columbia Habitat Program to encourage seeding of lower Wenatchee River tributaries with a locally-developed stock. Leavenworth NFH should place an emphasis on development of a “Leavenworth" stock, which would be used for outplanting in Icicle, Peshastin, and Chumstick creeks (if passage barriers to these habitats are improved in the Mid-Columbia Habitat Program).

Entiat Watershed

In the Entiat Watershed, all spring chinook salmon spawn upstream of its confluence with the Mad River, primarily because stream channel conditions and water temperatures in this upper reach are more favorable for late-summer spawners (Mullan et al. 1992; Carie 1995; Bugert et al. 1997a). At this time, all spring chinook salmon are released directly from Entiat NFH, downstream of this reach. The HWG believes that this strategy does not encourage seeding of these habitats or gene flow between hatchery and natural fish. No marked fish from Entiat NFH have been recovered in the upper Entiat Watershed (Kelly 1995; Carie 1996a; 1996b). If this population is to be supplemented, releases of acclimated smolts should be made from locations upstream or proximal to the spawning areas. Winter and early spring access to the upper watershed is relatively good, which should allow an extended acclimation. At this time, no means is available to intercept the run-at-large for broodstock; only those adults that return to the hatchery ladder are used. This does not allow a random sample of hatchery and natural adults for broodstock. The HWG believes that alternative means to collect broodstock should be developed if a supplementation program is initiated.

Methow Watershed

Virtually all spring chinook salmon in the Methow Watershed spawn in its two largest tributaries (the Twisp and Chewuch rivers), and in the mainstem Methow River upstream of the Chewuch River confluence. Although they had no genetic data to verify their assumptions, the HWG felt that there is a higher propensity for gene flow among the spawners in the upper Methow, Chewuch, and Twisp rivers than in the Wenatchee Watershed. They based this on four factors:

(1) Unmarked hatchery-origin salmon have been detected in each of the three spawning areas, which are presumed to be mostly from Winthrop NFH (Carie, USFWS, pers. comm.) and marked fish from the Chewuch acclimation pond have been found in the mainstem Methow and Twisp rivers (Brown, WDFW, pers. comm), indicating the potential for some level of gene flow among the Methow, Twisp, and Chewuch populations. The incidence of Leavenworth NFH fish in the upper Wenatchee Watersheds is not as high;
(2) The three spawning areas are geographically close together, giving a higher likelihood of natural migration from one stream to another;
(3) The Wenatchee Watershed has more diverse conditions (most notably lotic and lentic habitats) that probably encourage more diverse life history strategies and local adaptation among the fish from separate tributaries than does the Methow Watershed; and
(4) Despite the separation of the three spawning habitats in the tributaries of the Methow Watershed, a significant portion of age 0 spring chinook salmon overwinter in the mainstem Methow River

(Hubble, YIN, pers. comm.) where the progenies of these separate spawners would be aggregated and probably exposed to similar selective pressures.

These factors lead the HWG to believe that risks of losing genetic diversity from consolidating the nominal Methow populations would be less than for the Wenatchee populations.

3.5: Risk Assessment

Escapement of spring chinook salmon to the Mid-Columbia Region has been variable but declining to levels where the risk of extinction to various stochastic factors is high (Section 1.5). The HWG felt that it is imperative to rebuild the population quickly to reduce the probability of extinction due to demographic, environmental, or genetic factors. The HWG agreed on four basic factors, which directed the deliberations on the most appropriate strategies for spring chinook salmon:

(1) Risks to natural populations are high enough that aggressive intervention should be used, including some strategies that would typically be considered too high risk for normal hatchery programs;

(2) Because of substantial uncertainties associated with each of the intervention strategies, the most reasonable approach for the Mid-Columbia Region as a whole is one that includes a diversity of strategies for component populations;

(3) The overall approach for conservation and recovery of spring chinook salmon should be developed in a way that could test the effectiveness of the alternative strategies considered by the HWG. The Mid-Columbia Region is large enough for the Mid-Columbia Hatchery Program to employ and compare differing hatchery strategies to increase abundance, manage gene flow, and allow and preserve local adaptation; and

(4) Because the ability of supplementation to lead to long-term improvements in abundance and sustainability of natural populations has not yet been documented--even for traditional adult-based programs--the diversity of approaches should also include some populations that are not supplemented. This recognizes the fact that, in spite of the risks faced by natural populations, we are not certain that the risks will be less using supplementation.

Several strategies for using artificial propagation to conserve and recover spring chinook salmon were considered by the HWG and the relative risks and benefits to the population were deliberated. Each strategy presented differing levels of risk, benefits, and feasibility, which are discussed below.

3.5.1: Propagation strategies

Five basic strategies for using artificial propagation to conserve and recover populations of spring chinook salmon in the Mid-Columbia Region are (1) low, medium, and high levels of supplementation of natural populations (2) separate management and propagation of discrete populations, (3) consolidation of two or more populations into larger gene pools (Section 3.5.4), (4) captive rearing of some portion of the natural populations through their entire life cycle, and (5) infusion of non-native gametes into the gene pools of selected hatchery groups.

(1) Varying levels of supplementation

In broad terms, “supplementation” connotes the collection, rearing, and release of locally adapted salmon in ways that promote ecologic and genetic compatibility with the naturally produced fish. The HWG assessed the genetic and ecologic implications of supplementing the populations at various levels, ranging from a small component (30% of the population in a given year class would be artificially propagated) to a very high component (60% to 90% in artificial propagation). One must consider the relative risk to the population from either allowing them to spawn naturally or to place them in artificial propagation.

Collection and propagation of "at-risk" populations may be prudent when the overall risk to catastrophic mortality in the hatchery (due to human or mechanical error) is perceived to be less than the natural causes of mortality (river conditions, predation, and climactic events). Further, the risks to the population from artificial propagation from genetic and ecologic risks must be considered when weighed against other alternatives.

In conjunction with the relative risks of artificial versus natural rearing, there are risks related to the potential for poor reproductive success in years of low spawner densities (Allee 1949; Andrewartha and Birch 1954). Based on NMFS recommendations for collection of broodstock for endangered Snake River spring chinook salmon populations, an upstream escapement of approximately 80 adults per population is probably a safe "minimum escapement" for natural spawning. This criterion may be revised however, based on an analysis of (1) spatial segregation of adults on the spawning grounds, (2) the variation in time of returns and spawning of the population, (3) the duration that individual fish are sexually mature and capable of spawning, and (4) the sex ratio of the spawning population, among other factors. These data will be gathered as part of the hatchery evaluation plan (Section 3.7), providing the Mid-Columbia Hatchery Coordinating Committee the information needed to allocate spawners in an appropriate manner.

(2) Propagation of discrete populations

In general, supplementation programs target the most discrete unit possible for propagation, ensuring a high level of genetic distinctiveness and local adaptation (Steward and Bjornn 1990; Bowles 1995). The HWG assessed the appropriateness of the SASSI-defined reproductive units as the level for collection, segregation, and propagation. They then compared these reproductive units against the assumed ecologic and genetic separation of spring chinook salmon populations in the Mid-Columbia Region (Appendix E2). The assumed benefits of this separation are (1) an increased among-population variability and (2) a potential for developing locally adapted populations. The assumed detriments are (1) a reduced flexibility and production of the hatcheries and (2) a general inability to propagate all reproductive units equally. Data on these factors were not sufficient for the HWG to determine the appropriate separation of populations for propagation. The HWG used the ecological and genetic data available to separate populations in a way that balanced the logistical limitations of terminal area collection and release of populations, maintenance of genetic integrity and local adaptation, and management of discrete populations.

(3) Propagation of composite populations

Combining populations in the Mid-Columbia Hatchery Program is a high risk strategy that should be used with caution, because (1) genetic, ecologic, and life history information suggests that the strategy may harm natural populations, and (2) the consequences of mixing may be irreversible. However, there are advantages to this strategy, mostly in the logistical feasibility of propagating a single, larger population than several small ones. Under certain circumstances, this may overcome genetic problems related to inbreeding depression, or this approach would be regarded as beneficial if the presumed risk to the population(s) from losing within-population variability is less than the presumed risk from extinction. This translates then, into an increased likelihood of increasing the abundance of fish and the populations' recovery over a shorter time frame.

One generation of spring chinook salmon in the Mid-Columbia Region was combined during the GCFMP (1939-1943). This undoubtably led to substantial mixing of fish from different populations. In spite of this mixing, some level of population distinctiveness could have been maintained, and some allozyme data support this contention. Given this background, the HWG felt that the use of combined populations may be justifiable if done in one watershed (the Methow), with the other major watershed (the

Wenatchee) being used for finer-scale population-specific management using a diversity of approaches (adult-based supplementation, captive rearing, and a non-intervention stream).

(4) *Captive rearing*

The HWG considered the use of captive rearing to restore depleted wild populations to be a high risk, unverified approach. The uncertainty of this approach lead the HWG to consider using it for only a few populations in which (1) genetic and demographic data indicates some unique population-specific attributes, and (2) the likelihood of carrying out the program is relatively high. The advantage of captive rearing is the capability to rapidly increase the abundance of a population over a relatively short time (possibly two generations). Disadvantages of captive rearing include (1) the potential for adverse genetic changes, including selection and domestication, and (2) a higher potential for loss of fish through facility failure than traditional hatchery programs. The HWG recommends that all the captive rearing programs should be held at two separate locations, if feasible, to prevent catastrophic loss to the captive reared populations.

(5) *Infusion of non-native gametes*

The HWG debated whether some hatcheries should introduce non-native fish into their broodstocks to increase the abundance of the population during years of poor escapement. This alternative was rejected, because of genetic impacts to the native population, and the general assumption that these non-native fish would have poor homing fidelity and return rates, relative to native populations (Bams 1976; Reisenbichler 1988).

3.5.2: Collection strategies

An effective population size (Ne) of at least 50 adults per generation is required to reduce the risk of inbreeding depression and genetic drift in the short term (fewer than 5 salmon generations; Nelson and Soule 1987). Waples (1990) showed that for Pacific salmon, the Ne to be approximately equal to the effective number of breeders per year (Nb) times the average generation length for the population. Thus, for a chinook salmon population with an average age at maturity of 4 years, the effective population size would be four times the harmonic mean of the Nb in four successive years. For a supplementation program in which natural and hatchery components interact extensively, the key factor is the effective size of the hatchery/wild system as a whole. Determining the levels of inbreeding and genetic drift in this hatchery/wild system is complex (Ryman and Laikre 1991; Waples and Do 1994). However, a key determinant is the number of adults taken for hatchery broodstock each year. If this number is small and hatchery productivity is high relative to that of wild fish, the result could be a considerable decrease in overall ne.

One approach that can minimize this risk is to take a large enough number of broodstock each year. In this way, even if the only contribution to future generations is from the broodstock taken into the hatchery, future generations will be derived from an adequate genetic base. The above considerations suggest that Ne = 500 per generation can be achieved with Nb = 100 - 150 for 4 consecutive years. Because effective size is typically much smaller than the number of breeders, use of approximately 250 pairs per year may be a reasonable goal to achieve Ne of at least 500 per generation. If fewer adults are available, it will be important to scale production to ensure that their progeny do not overwhelm the population as a whole (Waples, NMFS, pers. comm.).

The other important genetic concern related to collection is the potential for selectivity. The ideal collection strategy involves a random sample from the run at large, providing a broodstock that is representative of the entire population in terms of genetic diversity. The genotypic composition of the population cannot be determined during collection, so indicators of the population's characteristics must be used, including natural and hatchery parentage, run timing, sex ratio, age structure, and other demographic traits. These characteristics must be compared with historical collections, and with brood-year specific traits.

Two basic approaches for collection of broodstock were considered: the age of collection, and the location of collection. The advantages and disadvantages of the various strategies are discussed below:

Age at collection

The population can be sampled for broodstock at several life stages: adults as they are actively migrating upstream to the spawning grounds, adults on the spawning grounds, eggs or pre-emergent fry taken from the redds during incubation, post-emergent fry taken from the rearing areas, and pre-smolts and smolts captured as they move downstream from the rearing areas. In general, the earlier the sample is taken, the greater survival advantage is given to the propagated fish, because they are protected from natural causes of mortalities for a greater portion of their life. However, there generally are more logistical difficulties in collecting samples at early stages.

The benefits of collecting upstream-bound adults include: a survival advantage of gametes spawned and incubated in captivity, effective control of vertically transmitted diseases, an unbiased collection by sex of the fish, and if the trap is effective, an ability to manage the number and origin of fish to be propagated at the hatchery versus released for natural spawning. Specific problems involved in trapping adults include: effectiveness of collecting a random sample of the population, collecting enough of the population, impeded passage or displacement of target and non-target species, and potential impingement and prespawning mortality of adults on barrier traps.

Gaffing adults on the spawning grounds was tried for the Chiwawa FH spring chinook salmon broodstock in 1989 and 1992, and was discontinued. Specific problems involved in gaffing adults include: difficulty in locating and capturing adults, difficulty in collecting an equal sex ratio, inability to treat against vertical transmission of diseases, and disruption of spawning behavior of fish that are not collected.

Egg or pre-emergent fry collection has been used on several populations in the Pacific Northwest. This is typically done by hydraulic redd sampling (McNeil 1964; Young and Marlowe 1995). The advantages of this approach include: an ability to collect a known and representative sample of the entire population, limited disruption to the target and non-target fish, allowance for natural mate selection, knowledge of the number of families contributing to the broodstock, and an ability to avoid full-sib matings. The disadvantage of pre-emergent fry collections is that the survival advantage of artificial rearing is lessened because holding, spawning, and initial incubation are in the river, the effective number of breeders contributing to the broodstock may be substantially less than expected because one dominant male may spawn with several females, and the fish health history of the adults is unknown. Since considerable natural mortality has occurred by the time the fish are collected, a proportionately larger sample is required for artificial propagation.

Post-emergent fry collections can be used to collect broodstock (typically by electrofishing or seining), and often can yield sufficient fish for propagation. The disadvantages include the decreased survival benefits because of the late stage in sampling (similar to pre-emergent fry sampling), and no information on the number of families represented in the sample. These same concepts apply to collection at the pre-smolt or smolt phase.

Location of collection

In many supplementation programs in the Pacific Northwest, a concerted effort has been made to construct broodstock collection facilities on small-order streams close to where the populations spawn. The purpose of these traps is to ensure that discrete populations are exclusively collected, reducing the risk of outbreeding depression for the target population to be supplemented (RASP 1992). This is the foundation of the supplementation concept--that which encourages ecologic and genetic fitness--yet is undoubtably the most difficult objective to meet. For hatcheries that supplement stream-type chinook salmon (Healey 1983) and steelhead, most (if not all) of the terminal area traps are proximal to spawning and rearing areas, which in essence means that these traps are located in relatively high elevation, high gradient reaches of the Cascade and Rocky mountains. The terminal area broodstock traps in the Mid-Columbia Region are on these rivers: Twisp, Chewuch, Methow, Chiwawa, and Wenatchee. In one respect or another, each of these traps has failed to meet their objectives, despite several years of "adaptive management" to rectify design or operational problems (Hevlin and Rainey 1994). This predicament poses a significant risk to conservation hatcheries: selectivity in broodstock collection (Currens and Busack 1996).

The concept of trapping more than one nominal population at a common point is the alternative to the terminal area trap. The advantages include: unimpeded passage of target and non-target fish through the tributary traps, random collection of broodstock without significant risk of injury to the fish, an unambiguous count of fish as they reach the collection point, and a means to separate hatchery and natural fish for broodstock. The disadvantage is the inability to separate the discrete populations from one another. Wells Dam was used in 1996 as a common collection point for the Methow River populations, because of the poor efficiency of the traps on the Twisp and Chewuch rivers (Section 3.2.2). Likewise, Tumwater Dam on the Wenatchee River has an effective trap, but does not have the capability to separate the four upper Wenatchee River populations.

3.6: Preferred Recovery Strategies

The HWG identified and evaluated a number of approaches for each watershed, and developed intervention strategies that were genetically and ecologically appropriate for each population (Table 18). The HWG placed an emphasis on two complementary philosophies for management of spring chinook salmon within the Mid-Columbia Region: (1) there is general agreement on the need to encourage local adaptation of specific populations, but the ecological and genetic mechanisms by which this occurs, the management strategies that would best preserve this mechanism, and its overall significance to the success of rebuilding are not clearly understood. The general approach within the region should have the means to test the effectiveness of alternative strategies for population management; and (2) the HWG agreed that “spreading the risk” by selecting several alternatives for artificial propagation may be the most prudent approach to rebuilding the populations. Until more information on the genetic structure and population dynamics of Mid-Columbia spring chinook salmon are available, the HWG believes this strategy should be followed. Their expectation is that this strategy will increase the abundance of spawners in the short term, while providing the nominal populations the conditions necessary for maintenance of genetic integrity and local adaptation in the long term. As established, this plan may then be revised as the necessary information becomes available from the monitoring and evaluations (Section 3.7).

3.6.1: Wenatchee Watershed

The preferred strategy for production of spring chinook salmon in the Wenatchee River is to use a combination of supplementation, captive rearing, non-intervention, and modified production at Leavenworth NFH. Adult-based supplementation will continue on the Chiwawa River using the satellite facility for the RIHC, yet the production objective will be reduced from 672,000 to 300,000 yearling smolts. Captive rearing will be done with eggs and/or juveniles exclusively collected on Nason Creek and the White River, and no action will be taken on the Little Wenatchee River in Phase A of the Mid-Columbia Hatchery Program (Table 18). Leavenworth NFH will develop a local broodstock to supplement habitats made accessible through the Mid-Columbia Habitat Program, and to contribute to the rebuilding of populations within the lower Wenatchee Watershed.

Adult-based supplementation

The HWG elected to maintain the existing supplementation for the Chiwawa population because preliminary recoveries of marked hatchery fish from the program suggested a replacement rate that was 13 to 15 times that of naturally produced salmon. Note however, that the natural cohort replacement rate of hatchery fish is not known. Drawbacks from this program included (1) the difficulty in obtaining an appropriate sample for broodstock, (2) the potential for displacement or impedance of migrating adults, and (3) the risks attendant with all forms of artificial propagation regarding genetic fitness, selection, straying, and distribution of returning adults on the spawning grounds. Regardless, this strategy had the highest benefit and least risk of all alternatives considered.

Table 18. Summary of hatchery production strategies for spring chinook salmon populations in the Mid-Columbia Hatchery Program.

Watershed / Population	Strategy
Wenatchee	
Chiwawa	Continued adult-based supplementation using local population collected at Chiwawa weir. Phase A production is reduced from 672,000 to 300,000 yearling smolts.
White	Egg and juvenile-based captive rearing program using local population collected in White River.
Nason	Egg and juvenile-based captive breeding program using local population collected in Nason Creek.
Little Wenatchee	Defer artificial propagation until other populations have recovered; use as a “reference” population for hatchery intervention.
Leavenworth	Continue propagation, with emphasis on development of locally-adapted population. Initiate a reintroduction program for upper Icicle Creek and Chumstick Creek. Outplant into Peshastin Creek.
Entiat	
Entiat	Continue the current production program until the genetic and demographic assessment of hatchery and natural fish is completed. If the two components appear reproductively integrated, develop and maintain a locally-adapted Entiat population. In addition to ongoing program, initiate a supplementation program for upper Entiat River. Additional production capability will be 200,000 yearling smolts. Emphasis will be placed on natural rearing. If the natural population appears to be reproductively isolated from those reared at Entiat NFH, develop a strategy to monitor that population as a non-intervention “reference” group.
Methow	
Methow	Develop an adult-based supplementation program based on a single Methow Population. Collect run-at-large at Wells Dam, and spread production proportionately among the three streams. Initially, maintain Winthrop NFH population as a separate mark group for eventual transition into the use of the native Methow Population.
Chewuch	Same as Methow Population.
Twisp	An adult-based supplementation and an egg and juvenile-based captive brood program will be done concurrently. Mark smolts released from these programs differently from the Methow Population.

Of the four spring chinook salmon populations in the Wenatchee Watershed, the Chiwawa population appeared to have the least risk of extinction (Appendix D),and did not require a highly intensive intervention strategy for recovery. However, the HWG believed that the current production objective for the Chiwawa program (672,000 smolts) was higher than necessary for recovery of that population, and may place an additional risk to the natural salmonids. The production objective was reduced to 300,000 yearling smolts which, based on expected hatchery release to adult survival rates (Table 3) and estimates of stream wetted area, should more closely meet full seeding of that stream. Further, this reduced program would make some rearing water and space available for propagation of the Nason Creek and White River populations.

Juvenile-based captive rearing

As previously stated, the HWG believed the most appropriate intervention strategy for the Nason Creek and White River populations was an 8-year captive rearing program. This strategy was chosen because it had the highest potential to rapidly increase the number of fish from each population, while attempting to maintain the genetic separation of each population. The HWG established initial production objectives of 360,000 yearling smolts for the Nason Creek population and 240,000 yearling smolts for the White River population based on (1) the reproductive potential of chinook salmon held in a captive rearing program, (2) an estimate of the current and historic smolt production capacity of the two streams, (3) the expected survival rates of fish held in captivity, and (4) the capacities of the facilities to be used in the program. To obtain a representative genetic sample of the natural population, egg and pre-emergent fry collections from each river are more feasible than adult collections for founding the captive broodstock. Fry from at least 25 families (redds) will be used each year.

The HWG identified several genetic, natural production, and artificial production objectives for the captive rearing project. These objectives were based on (1) the expected number of redds in the streams that would provide the donor source, (2) the effective population size that maintains the genetic integrity of the populations, and (3) reducing risks of the collection strategy to natural productivity. These objectives are discussed below:

<u>Genetic objectives:</u>

(1) Collect a representative sample of the total population to found the broodstock program and to lessen the risk of genetic bottleneck. Sample 25 - 30 chinook salmon families throughout the target streams each year for eight consecutive years (1997 - 2004). If escapement to the stream produces less than 25 redds, all redds will be sampled.

(2) The captive broodstock spawning protocol will identify individual spawners by reading tags prior to spawning, avoid full-sib matings, use 1:1 spawning techniques, and record all spawning crosses.

(3) The captive rearing program will be done for no more than two consecutive salmon generations (8 years) to lessen the risk of domestication effects.

(4) The number of spawners derived from each family (redd) will be equalized as much as possible by random selections in order to minimize the variance in family size.

<u>Natural production objectives:</u>

(1) Allow natural production to continue concurrent with the captive rearing program by limiting the removal of pre-emergent fry from each redd and monitoring the post-emergent fry collection adjacent to each redd.

(2) Design and implement experiments to estimate the level of mortality on the naturally produced fish caused by the sampling techniques. Modify the sampling technique if collection-induced mortality exceeds 25%.

Artificial production objectives:

(1) Obtain 1,000 to 1,500 pre-emergent fry from each population each year, based on a sample of 40-50 eggs from 25 to 30 redds (Table 19).

(2) Augment shortfalls in pre-emergent fry collections by beach seining post emergent fry in the vicinity of unsampled redds. The actual number of fry to collect will be based upon the success of the pre-emergent fry collections. Sampling will be done throughout the spawning areas over a period of several weeks to increase the likelihood of obtaining fry from a large number of families. Collection of pre-smolts or smolts using downstream migrant traps also may be used to augment pre-emergent fry collections. For all methods, collections will not exceed production numbers listed above.
The pre-emergent fry collections will take priority over the post-emergent collections because the former gives direct information on the number of families sampled, it prevents full-sib matings, and a smaller proportion of the natural population need to be sampled to meet the production objectives. however, managers may assume the post-emergent collections are from families different from the pre-emergent fry collections.

(3) Maintain family integrity throughout the project by keeping each in separate rearing units until tagging. Each family will have a unique CWT code.

(4) Rear fry to spawning adults with a total survival of 30% or more in each family (Table 19). All fish will be reared at or below a density index of 0.125 lbs./cubic ft./in.

(5) Release second-generation smolts using techniques comparable to adult-based supplementation programs.

Table 19. Summary of actions for captive rearing of spring chinook salmon in the White River, Nason Creek, and Twisp River.

	First generation			Second generation	
Population	Redds to be sampled	Eggs taken per redd	Adult objective[1]	Eggtake objective[2]	Smolt objective[3]
White River	25	40	300	300,000	240,000
Nason Creek	30	50	450	450,000	360,000
Twisp River	30	45	405	405,000	324,000

[1] *Based on an assumed 30% egg to adult survival rate.*
[2] *Based on an assumed sex ratio of 1.0:1.0 and fecundity of 2,000.*
[3] *Based on an assumed 80% egg to adult survival rate.*

The HWG considers captive rearing to be an experimental tool for the conservation and recovery of natural populations. While the theoretical advantage of captive rearing (a rapid increase in abundance) is evident, this strategy may also increase the risk of genetic impacts (domestication, selection, and drift) or large scale mortalities from facility failures. The HWG felt that the most prudent approach was to keep most of the fish from each family in natural production, and to reduce the overall time period the population would be reared in captivity. Fish reared in captivity for their entire life cycle are exempt from many natural selective pressures. This greatly increases the risk of genetic changes from the donor population within a few salmon generations. For this reason, the HWG felt that the captive rearing programs should be short in duration, based on the expectation that measures in the Mid-Columbia Mainstem and Habitat programs will begin to correct the factors causing the decline of these populations within 8 years of MCMCP implementation.

Leavenworth NFH

The production objective at Leavenworth NFH will remain essentially the same in Phase A of the Mid-Columbia Hatchery Program, yet the facility may be modified to (1) encourage development of a locally-adapted population, and (2) work in conjunction with the Mid-Columbia Habitat Program to reintroduce spring chinook salmon to Icicle and Chumstick creeks (after the passage barriers are removed or altered), and to outplant into Peshastin Creek (Table 20). To accomplish this, an acclimation site may be required for upper Icicle Creek (150,000 yearling smolts at 15 fpp); smolts and presmolts would be outplanted into natural rearing areas or temporary acclimation ponds on Chumstick and Peshastin creeks. Development of this "Leavenworth" stock would involve collection of adults naturally returning to Leavenworth NFH (although an upstream migrant trap may be installed when Leavenworth Dam is modified, allowing collections for broodstock), and the restriction on the use of non-native populations for broodstock.

Non-intervention population

The HWG chose the Little Wenatchee River and Entiat River populations as the most suitable groups to exclude from hatchery intervention. The Little Wenatchee River population was considered to be most appropriate because (1) escapement is currently very low, precluding options for collection of a locally adapted broodstock, and (2) the geographic isolation of this stream limits access for installation and operation of facilities (acclimation sites and traps). The natural productivity of this population will be monitored throughout Phase A of the Mid-Columbia Hatchery Program, allowing the Mid-Columbia Hatchery Coordinating Committee to evaluate the benefits of non-intervention and the stream's use as a reference. The committee may elect to begin artificial propagation of this population at a later date. Colonization of this stream by other Wenatchee Watershed populations may occur. The HWG is currently assessing the merits of non-intervention on the Entiat River (Section 3.6.2).

3.6.2: Entiat Watershed

The genetic relation between the fish produced at Entiat NFH and those fish that spawn naturally in the upper Entiat River is not understood (Section 3.3). The HWG believes that development of a recovery program for Entiat River spring chinook salmon should be based solely on this natural native population, if the fish produced at Entiat NFH are determined to be dissimilar to the natural production. Given the uncertain relation between the Entiat NFH fish and the natural population, the least risk approach for this interim period is to maintain production at current levels and evaluate the means by which Entiat NFH may lessen impacts, if any, to the natural population.

If it is determined that the natural population is reproductively isolated from the hatchery population, the Mid-Columbia Hatchery Coordinating Committee will review the options available for recovery. Given their emphasis on the complementary philosophies of (1) spreading the risk of various intervention strategies on the recovery process, and (2) the need to evaluate the effectiveness of the selected strategies, the HWG recognized the importance of selecting populations for use as "reference groups," where they would not be artificially propagated. The Mid-Columbia Hatchery Coordinating Committee will investigate the feasibility of recovering the Entiat population using methods other than artificial propagation, and monitor its sustainability using ecologic indicators. If this strategy is determined to be deleterious to the ESU as a whole, a hatchery intervention plan based on the natural population will be developed.

Table 20. Modifications of the spring chinook salmon production objectives at Leavenworth Complex to meet the combined Phase A Mid-Columbia Hatchery Program and CRFMP goals.

Facility Production objectives	Description
Leavenworth NFH	
Current	Release 1,620,000 yearling smolts into lower Icicle Creek.
Phase A	Meet current objectives, but a lower Wenatchee River stock will be developed. Most fish will be released directly from the hatchery into lower Icicle Creek, yet some will be outplanted into upper Icicle, Chumstick, and/or Peshastin creeks.
Entiat NFH	
Current	Release 400,000 yearling and 400,000 subyearling smolts into lower Entiat River.
Phase A	Maintain current program and determine relation of Entiat NFH fish and natural spawners. If the two groups appear to be reproductively integrated modify program to release up to 600,000 yearling smolts into lower Entiat River and outplant 200,000 yearling smolts in upper Entiat River. Operate on a supplementation concept, as defined by RASP (1993). If the two groups are reproductively isolated, develop a strategy to recover and conserve the natural population using methods other than artificial propagation, if possible.
Winthrop NFH	
Current	Release 800,000 yearling smolts into Methow River at Winthrop.
Phase A	Initial production will be 600,000 yearling smolts, which will be increased to 800,000 after rearing capacity at the hatchery is increased.

The fish produced at Entiat NFH should be further integrated with the natural population for the recovery program if analyses show the two populations to be reproductively integrated. At this time, the HWG believes that the existing hatchery program in the Entiat River does not contribute to the conservation and recovery of spring chinook salmon. If Entiat NFH is to be used in the rebuilding process, the hatchery program must be modified to (1) encourage gene flow between natural and hatchery fish and (2) promote natural productivity. If no detectable differences are observed between the hatchery and natural fish, the HWG will establish two separate production programs for the Entiat River, with the expectation that these two programs would merge into one stronger program in subsequent years. The first program is to maintain the existing production objective for Entiat NFH (Tables 18, 20) while initiating a series of measures to increase gene flow between hatchery and natural production, and the overall production of natural spring chinook salmon in the Entiat River. The second program will place emphasis on natural rearing and acclimation of presmolts and smolts to increase natural production.

At this time, there is no program on the Entiat River with an objective to supplement natural production, although efforts are being made to make Entiat NFH more consistent with this approach (Shelldrake 1993). Use of a local stock is preferred, but not emphasized. Entiat NFH is located downstream of spring chinook salmon spawning and rearing habitat, so there is limited potential for gene flow between those fish reared in the hatchery and those that spawn naturally. This could be rectified by placing acclimation and release sites at some points close to most spawning and rearing areas.

The most important consideration for developing a supplementation program on the Entiat River would be in broodstock management. An upstream migrant trap (or some means to intercept and collect both hatchery and natural salmon for broodstock) will be developed. This trap will have two purposes (1) allow a count of escapement to the river, and (2) allow a random collection of natural and hatchery fish for broodstock. However, many difficulties in upstream trapping have been experienced in other Columbia River programs, so this consideration should be thoughtfully reviewed, and all options should be explored, before the trap is constructed. Most of the lands adjacent to the river from Burns Creek downstream are privately owned, which may limit options for trap placement. There are some human-made structures on the mainstem Entiat River that restrict flow. These sites may be suitable for modification to collect upstream migrants. This trap should be designed to intercept upstream-bound summer chinook salmon (Section 2) and steelhead (Section 4) in addition to spring chinook salmon. The existing ladder and weir near Roaring Creek would be used to augment collections.

Acclimation and releases of smolts in upper reaches of the watershed are feasible, as access to suitable locations is relatively good throughout the year. An acclimation pond will be built on the Entiat River near the Preston Creek confluence (or other appropriate site) for release of 200,000 yearling spring chinook (20,000 lbs at 10 fpp). If an acclimation pond is developed for steelhead (Section 4.6.2) the site should be developed as paired acclimation ponds, allowing greater operational and experimental capabilities.

There are several private owners of high quality side channels that appear to be willing to do cooperative ventures to outplant salmonids. The following are potential acclimation sites that may be developed for the Mid-Columbia Hatchery Program through a collaborative effort with the Mid-Columbia Habitat Program:

(1) The privately owned side channels near the Brenegan Creek confluence (RK 39) could be used to acclimate spring chinook salmon, using a natural rearing strategy.
(2) A cooperative venture could be developed with the Roundy Irrigation District to acclimate spring chinook salmon in the McKenzie Ditch (RK 24), using a natural rearing strategy. Salmon could be introduced in early spring at 20 fpp (2,500 lbs), and fed periodically.
(3) A cooperative venture could be developed with managers of the Firehouse irrigation channel (RK 6), to overwinter rear and acclimate 25,000 spring chinook salmon (2,500 lbs at 10 fpp), using a natural rearing strategy. Limited feeding and maintenance would be provided by Entiat NFH staff. Smolts would be transferred from Entiat FH (1,670 lbs at 15 fpp) in October, for volitional release through winter and spring. Some modification to the headgate would be required.
(4) A small moderately controlled acclimation pond could be built on the lower Mad River (Tillicum Creek confluence) for 40,000 spring chinook salmon (4,000 lbs at 10 fpp). Given the right conditions, these fish could be overwintered with limited maintenance.
(5) A small number (10,000) of spring chinook salmon fry could be released into the flood-prone side-channels adjacent to Entiat NFH. These fish could be scattered there in fall or early spring, prior to the freshet.

The HWG recommends that the subyearling program at Entiat NFH be modified to a yearling program. If additional groundwater rights could be obtained, some additional late summer rearing could be achieved at Entiat NFH. If this capability is realized, the 400,000 subyearling spring chinook salmon could be reduced in number to 200,000, and reared through the yearling stage (20,000 lbs at 10 fpp). Moreover, this stock could be changed to Wells summer chinook salmon (derived from volunteers), with the intent of developing a local broodstock. If additional groundwater cannot be obtained, the 400,000 subyearling spring chinook salmon should nevertheless be changed to summer chinook salmon (Section 2.6.2). The Mid-Columbia Hatchery Coordinating Committee will review these options when developing the strategy for spring chinook salmon in the Entiat River.

3.6.3: Methow Watershed

Conceptual approach:

The supplementation program for Methow spring chinook salmon was developed after considering their historic and current population dynamics and genetic structure within the watershed. Information on these factors was limited, consisting mainly of information on the GCFMP, recent fishery management actions, spawner/ recruitment ratios, ecological data, and electrophoretic data. Collectively this information allows a variety of interpretations regarding population structure in the Methow Watershed. At one extreme, each population in the basin can be viewed as historically isolated, with some mixing imposed by management actions in recent decades. At the other extreme, the basin can be viewed as historically comprising a single gene pool that spawned in a variety of habitats. Any number of intermediate states could also describe past and current relationships of spring chinook salmon in the Methow Watershed. It is also possible that on some time scales spring chinook salmon in the Methow Watershed behaved as a metapopulation. Because of these uncertainties, and the desire of the HWG to spread the overall risk of various hatchery intervention strategies to spring chinook salmon in the Mid-Columbia Region, the plan chosen was to enlarge the overall population size by managing fish from the Methow, Chewuch, and Twisp watersheds as one gene pool. However, efforts will be made to captively rear fish from the Twisp River, to maintain genetic integrity of this population and to allow more management flexibility in future years. Of the various strategies considered, the HWG believed that this strategy has the highest probability of successfully leading to recovery of spring chinook salmon in the Methow Watershed, and reflects the uncertain information about the population structure within the basin.

Some members of the HWG wished to exclude the existing Winthrop NFH stock in the recovery plan for the Methow population, because this population was founded approximately 20 years ago with out-of-ESU broodstock of mixed origin and has periodically received additional imports of out-of-ESU broodstock since that time (most recently in the 1989, 1990, and 1991 broods). For the years 1982 to 1994, 24.1% (range: 11.3% - 45.1%) of the Methow River escapement (as measured at Wells Dam) was comprised of Winthrop NFH origin salmon, and some of the natural spawners in the Methow River in some years appear likely to be of Winthrop NFH origin. In brood years 1993 to 1996, a large proportion (up to 100% in 1995) of the broodstock used at Methow FH was also made up of Winthrop NFH origin fish. Given the unknown degree to which the Winthrop NFH stock has already been integrated into the natural Methow gene pool, the HWG was uncertain of the degree of risk that additional integration of Winthrop NFH fish pose to the native natural population.

Some HWG members speculated that it may be possible to remove some or all of the Winthrop NFH returns in the next few years. To do this, overall abundance would have to be large enough in a given year to allow removal of marked hatchery fish from the gene pool without increasing the native fishes' risk of extinction from the demographic effects of low population size. Because the abundance of spring chinook salmon returning to the Methow Watershed may be extremely low for several brood years in the near future, the HWG decided that immediately eliminating the Winthrop NFH stock would not be the least risk course of action. Instead, the HWG agreed that the current spring chinook salmon population from Winthrop NFH should be phased out of production over a longer period, so that they may be used if spring chinook salmon abundance in the Methow Watershed in the near future becomes so low that the fish are needed to avoid extinction in the basin. The most feasible way to accomplish this is (1) in years when escapement to the Methow River is too low to warrant elimination of the Winthrop NFH fish, retain them for production, but spawn, rear, and mark them separately so they can be recognized as returning adults for potential exclusion; and (2) in years when returns of the Methow Population to the basin is high enough to exceed production objectives for Methow FH, the surplus will be transferred to Winthrop NFH and used to replace the Winthrop Population.

Given the expected low returns of spring chinook salmon to the Methow River in 1999 and 2000, the HWG anticipates that collection of all adults at Wells Dam for broodstock may be warranted. They assumed that the short-term adult-to-adult replacement rates were higher for fish reared to a yearling stage in a hatchery than those produced naturally in the wild (although data from the Methow FH evaluation plan were too preliminary to verify this assumption). In addition, based on reviews of other sources (Andrewartha and Birch 1954; Myers et al. 1995) the HWG believed that the reproductive success of naturally spawning fish may be reduced when their numbers are very low, primarily because of demographic factors. If fish are released upstream for natural spawning, sufficient numbers must be present to overcome these effects. After careful deliberation, the HWG agreed that 80 fish per stream would be a minimum number for natural spawning (based upon analysis of the sex ratio of the population, the size of the spawning area, the spatial and temporal segregation of spawners, and the duration that individual fish are suitable for spawning). Based on the recent average Methow Watershed spawning distribution of 27% Twisp River, 28% Chewuch River, and 45% Methow River, the combined escapement to meet the 80 fish criterion for the Twisp River would be 296 adults (80 + 83 + 133). When escapement to Wells Dam is sufficient to warrant release of fish for natural spawning in the Methow River, a minimum of 300 fish should be passed upstream.

Implementation:

Adult broodstock will be taken at Wells Dam to supplement the Methow, Chewuch, and Twisp rivers. This program will be augmented by captive rearing of pre-emergent fry collected on the Twisp River or from gametes of marked Twisp adults taken at Wells Dam. To ensure a stable rebuilding process and appropriate test of supplementation as a rebuilding tool, the adult-based supplementation program will take precedence over the Twisp captive rearing program (see discussion below). Smolts produced from the adult-based supplementation program will be acclimated and released into the Chewuch, mainstem Methow, and under certain conditions, the Twisp rivers (although efforts will be made to spawn, rear, and mark the Twisp fish separately). Second-generation fish from the Twisp River captive rearing program will be incorporated into the supplementation efforts.

Winthrop NFH will continue with its interim production objective (600,000 yearling smolts), yet will modify its production program to be more compatible with Methow FH. Production will be equally shared between the two facilities. Both programs will continue the overall management approach outlined in the Methow FH evaluation plan (WCC 1995): (1) management of hatchery facilities that encourages gene flow between natural and hatchery fish, (2) continued use of innovative fish culture strategies, and (3) rearing and release of hatchery fish that are similar to natural fish. As the population increases in abundance and begins recovery, production may be increased to 800,000 yearling smolts.

To meet the interim production objectives for the combined Methow/Winthrop programs, 668 adults will be required (306 for Methow and 362 for Winthrop). Production would be 550,000 yearling smolts (36,667 lbs. at 15 fpp) at Methow FH and 600,000 yearling smolts (40,000 lbs. at 15 fpp) at Winthrop NFH. The long-term production objectives will require 931 adults for broodstock, 449 for Methow FH and 482 for Winthrop NFH, to produce 738,000 and 800,000 yearling smolts, respectively.

Adult collection

An annual collection protocol will be established which reflects the balance in natural escapement objectives, production objectives for Methow and Winthrop fish hatcheries, and the Twisp River captive rearing program. Broodstock collection at Wells Dam will be conducted according to the following guidelines:

(1) Broodstock will be representative of the entire run to Wells Dam; both natural and hatchery fish will be incorporated into the broodstock.

(2) Adult collections will be based on a tiered approach that reflects a balance between risks associated with natural productivity at very low run sizes and those associated with capture and artificial rearing. The *interim production objectives* will be used until modifications to Winthrop and Methow fish hatcheries are made, thereby increasing their capacities.
Interim production objectives: When the run size to Wells Dam is expected to be 668 adults or fewer (as projected from lower river dam counts), all fish will be placed into the adult-based supplementation program. This will place both facilities at capacity. When the predicted run size is 669 to 964, a minimum of 296 adults will be passed upstream for natural spawning, resulting in a combined hatcheries' capacity of 56% to 100%. When the predicted run size is over 964, collection will be at levels required to meet the production objective.
Long-term production objectives: This strategy is based on the assumption that Winthrop NFH and Methow FH will be able to safely produce 800,000 and 738,000 yearling smolts at 15 fpp, respectively. When the run size to Wells Dam is expected to be 740 adults or fewer (as projected from lower river dam counts), all fish will be placed into the adult-based supplementation program. When the predicted run size is 741 to 1,415, 60% of the run will be collected for broodstock. The remainder will be passed upstream for natural spawning, thereby meeting the minimum escapement levels (296 adults). When the run size is more than 1,415, collection will be at levels required to meet the production requirement.

(3) Marked fish from outside of the Mid-Columbia Region will be excluded from the Methow broodstock. Adults captured at Wells Dam that are from the Entiat and Wenatchee programs will be returned to their origin, if this action in consistent with disease protocol. This will require reading of CWTs during spawning at both hatcheries.

(4) Adults will be PIT tagged (or individually marked by some means) to identify them by time of arrival. If too many adults are collected because the actual run size differs substantially from the prediction, adults will be selected for return to the river for natural spawning. This will be done in a manner that allows an adequate representation of the gene pool, and is consistent with ongoing disease prophylaxis treatments. Late arriving adults will be genotyped by biochemical or molecular genetic methods to ensure that ocean-type chinook salmon are not inadvertently included in the broodstock.

(5) Volunteers to Foghorn Ditch will be managed in a way that prevents the inadvertent collection of too many broodstock. This can be done at least two ways: (a) collections at Wells Dam will be reduced accordingly to allow collection of volunteers, or (b) Foghorn Ditch will be barricaded to prevent salmon from entering the hatcheries. Both strategies have risks. The Mid-Columbia Hatchery Coordinating Committee will review and develop the appropriate strategy.

(6) Gametes from marked Twisp River fish may be used for captive rearing, provided that (a) this program does not interfere with the adult-based supplementation program and (b) the guidelines for captive rearing (Section 3.6.1) are generally followed.

Twisp River captive rearing

To provide flexibility in management options and to increase the overall abundance of spring chinook salmon in the Methow Watershed, a captive rearing program will be established for the Twisp River. This program is expected to last a minimum of eight years (two salmon generations), with eventual releases of second-generation yearling smolts into the Twisp River. Guidelines for this captive rearing program will follow those established for the Nason Creek and White River populations (Section 3.6.1), although some additional factors were considered to ensure biological and logistical compatibility with the Methow adult-based supplementation program (discussed below).

Ideally, redds from those fish that spawn in the Twisp River will be sampled for captive rearing, but the HWG believes the most effective strategy for recovery during periods of very low escapement (predicted run sizes of 668 or fewer) is to place the entire population into the adult-based supplementation program. When this occurs, approximately 1% of the fertilized eggs from each marked Twisp River female will be transferred from the adult-based program to the captive rearing program. This will require the mating of Twisp males to Twisp females, if possible. Also, if possible, the remaining eggs from the Twisp River adults (those used in the adult-based supplementation program) will be propagated and marked separately from the Methow and Chewuch rivers, for release into the Twisp River.

When the predicted run size is high enough to allow the minimum escapement (296 adults released upstream of Wells Dam for natural spawning), the redds in the Twisp River will be sampled according to the guidelines established in Section 3.6.1. Up to 30 redds will be sampled for approximately 45 eggs each, for a projected second-generation smolt yield of 324,000 (Table 19). These fish will be given a unique mark and released into the Twisp River in an ecologically sound manner. The captive rearing program will not be required when the 5-year rolling average escapement to Wells Dam is over 2,000 fish.

At this time, the HWG recognizes that facilities will be required to accommodate the captive Twisp population. This is based on the premise that this program will not interfere with the interim or long-term production objectives for the adult-based supplementation program. To reduce the risk of catastrophic losses, the captive reared population should be physically separated from the adult-based supplementation program. This will require extensive coordination among the USFWS, WDFW, and YIN. The Mid-Columbia Hatchery Coordinating Committee will reduce or modify the captive rearing program if it compromises the effectiveness of the adult-based supplementation program.

Shared use of hatchery facilities

A concerted effort should be made to integrate Methow and Winthrop hatcheries into a unified program. There are several programmatic means to consolidate spring chinook salmon production on the Methow River, and several administrative means. The HWG recommends that the parties develop a memorandum of understanding between the two entities on shared use of facilities, fish, and water rights. To ensure compatibility, USFWS would follow those guidelines established in the MSP. Other administrative options could be pursued to make the current programs more efficient, and could be considered. Given proper administrative oversight, these hatcheries could readily assist one another, depending upon the current management needs. A detailed discussion of these options is beyond the scope of this assessment, yet it should be considered as part of the Mid-Columbia Hatchery Program.

Acclimation and release strategies

Four separate acclimation and release sites are available for the spring chinook salmon hatchery program: two on the mainstem Methow River (Methow FH and Winthrop NFH) and one each on the Chewuch and Twisp rivers. Three strategies for apportioning the numbers of composite population into these sites are: (1) divide the population equally for release into the three streams, (2) divide the population in proportion to the wetted area of each stream, or (3) divide the population based upon ranked priority in rebuilding one stream over the others (Cuenco, CRITFC, pers. comm.). The relative merit of each strategy was reviewed by the HWG. The preferred strategy will be developed and reviewed annually, based primarily on the numbers of fish in the river and hatchery.

3.7: Stray Fish Management

One objective of the Mid-Columbia Spring Chinook Salmon Hatchery Program is to meet population specific supplementation objectives with locally adapted broodstock. Some level of straying by marked hatchery fish among populations within the Mid-Columbia Region has been documented, and can be expected to continue. The HWG deliberated on the appropriate strategy for detection, tolerance, and control of hatchery fish that have strayed from points within, and outside of, the Mid-Columbia Region. It was recognized that the level of natural and hatchery-induced straying is not fully known, so the effect of this phenomenon is uncertain (Leider 1997). Given the fact that several strategies for hatchery intervention will be used in the Mid-Columbia Hatchery Program, the stray fish management plan needs to be flexible and adaptive. At this time, the most pragmatic approach for strays in the Mid-Columbia Region is based upon a hierarchy of tolerance levels, based on the particular watershed (discussed below).

Individual strays from release sites within the Mid-Columbia Region can be potentially transferred back to the program of origin. Management of strays from release sites outside the Mid-Columbia Region is more problematic, both in impacts to the population and in means to control them. The HWG recognizes that coordination throughout the Pacific Northwest Region is required to effectively manage strays. At a minimum, marked strays from outside the Mid-Columbia Region will be removed from the receiving hatchery population.

Straying from hatcheries into natural populations other than their intended target population will usually be detected only after the fact. If such strays are detected in numbers higher than the agreed upon goals, various options must be immediately explored to reduce the impact of straying. These might include altered rearing and release strategies in the program with high strays, decreased production in the program with high strays, or increased production in the program receiving the high level of strays. The option that maximizes the probability of recovery of the entire ESU while conserving its component parts should be chosen. Decisions regarding the fate of programs that produce high stray rates will be based on a joint evaluation of the genetic and demographic costs and benefits of straying to both the donor and the receiving population. Evaluations will be done on a case-by-case basis and will specifically consider whether the benefits of increased spawner population size due to straying balance or outweigh the genetic risks of introgression.

This stray management plan should be considered as temporary, and will be further refined during the implementation of the Mid-Columbia Hatchery Program. Additional factors that will be considered in development of this plan will include, but not be limited to: (1) the origin of the strays, (2) their absolute number in (and percent of) the impacted population, (3) their persistence from year to year, (4) the impacted population's history of importing non-native fish, (5) the ability of the hatchery facilities to manage strays, and (6) performance of F_1 offspring of strays.

Wenatchee Watershed

In Phase A of the Mid-Columbia Hatchery Program, five populations will be separately managed in the Wenatchee Watershed. Management for strays in this watershed will be the most rigorous in the Mid-Columbia Region. All hatchery fish used for supplementation and reintroduction programs will be marked unique to the population. For adult-based hatchery broodstock collections, gametes of any stray fish from within the Wenatchee Watershed, or from the Entiat or Methow watersheds will be transferred to the program of origin, if this action is consistent with disease protocol. The Mid-Columbia Hatchery Coordinating Committee will determine on a case by case basis the appropriate action for managing strays in the juvenile-based hatchery programs. The incidence of stray fish in the captive rearing programs will be reviewed yearly to weigh the relative benefits and detriments of continuing the captive program, and to determine the appropriate means to propagate and release those fish on station. A key component of this assessment will be estimates of the rate of straying within the Wenatchee Watershed of naturally produced fish.

Entiat Watershed

At this time, the genetic relation between the fish produced at Entiat NFH and those naturally spawning in the upper Entiat Watershed is not understood. The HWG expects to better understand the relation of these two groups soon, as the fish are currently being sampled for electrophoretic analysis. In the interim, no efforts will be made to control gene flow between the two. However, marked hatchery fish from either the Wenatchee or Methow watersheds that are collected at Entiat NFH will be transferred to the program of origin. This will require reading of CWTs from marked fish during spawning, and the capability to incubate these groups separately.

Methow Watershed

Spring chinook salmon destined for the Methow Watershed will be collected at Wells Dam, providing fish to all suitable tributaries in that basin. Natural and hatchery fish from the Chewuch, Methow, and Twisp rivers will be allowed to spawn in any area of the Methow Watershed. The CWTs of marked fish will be read during spawning at Methow and Winthrop fish hatcheries. Efforts will be made to isolate marked fish released from the Twisp Acclimation Pond for separate propagation. If feasible, these fish would eventually be used for either the captive rearing program or for a yearling smolt release into the Twisp River. If held separately, the Twisp fish would be given a unique mark. Gametes from marked fish originating from the Wenatchee or Entiat watersheds will be incubated separately and transferred to the program of origin.

3.8: Monitoring and Evaluation

The evaluation plans for artificial propagation of spring chinook salmon are aggregated into two components: the programs used for adult-based supplementation (Section 3.8.1) and those used for captive-rearing of fish throughout their life history (Section 3.8.2). Each component is meant to complement each other, provide information leading to adaptive management of spring chinook salmon, and be useful in the evaluation and management of the other Plan Species in the Mid-Columbia Region. The premise behind the evaluations for the Twisp captive rearing is that it will not affect the efficacy of the Methow adult-based supplementation evaluations.

3.8.1: Adult-based supplementation

The evaluation plan for the adult-based supplementation component addresses the three critical uncertainties identified in Section 1.9: (1) whether the hatchery facilities can safely meet their production objectives, (2) do these programs affect the long-term reproductive success of the population in the natural environment, and (3) are there ways to operate the facilities to reduce the short-term ecologic impacts to the naturally produced fish.

Objective 1: Determine if the facilities in the Mid-Columbia Hatchery Program are capable of meeting their production objectives.
Broodstock collection
Task 1.1: Document and evaluate trapping/collection of spring chinook salmon for broodstock.

- Evaluate the effectiveness of adult traps on selected rivers for collecting and holding salmon. Make recommendations, and assist with modifications, to improve the effectiveness of the trap for capturing and passing salmon.

- Monitor numbers of adult salmon holding upstream or downstream of the weir through periodic snorkel or carcass recovery surveys.

- Compare current redd densities and number of carcasses above and below the weir, as well as with earlier years, as an indication of the effects of the weir and trap on spawning distribution.

- Collect biological information on trap related mortalities. Determine causes of mortality, if possible.

- Keep daily records of trap management, number and condition of fish trapped, and river stage. Trap efficiency will be correlated with flow data.

- Provide recommendations to improve adult trapping and reduce delay or avoidance.

Task 1.2: Determine migration timing, movements, and habitat use of adult spring chinook salmon in selected tributaries in the Mid-Columbia Region.

- Evaluate the efficacy of the weir and adult trap for capture and passage of adult salmon at selected Mid-Columbia facilities.

Spawning practices
Task 1.3: Document and evaluate collection to spawning survival.

- Document adult holding and spawning practices, and correlate with changes in survival.

Incubation practices
Task 1.4: Document and evaluate fertilization to ponding survival.

- Document incubation practices, and correlate changes in egg survival, yolk absorption, or development with water temperature and source, treatments given, or other incubation practice.

Rearing practices
Task 1.5: Document and evaluate juvenile fish rearing at Mid-Columbia hatcheries.

- Monitor growth, densities, mortality rates, and feed conversion of yearling spring chinook salmon reared at Mid-Columbia hatcheries and acclimated at the ponds prior to release.

- Determine monthly, egg-to-fry, and fry-to-smolt survival rates for spring chinook salmon in the hatchery.

- Correlate survival rates and fish health with disease prophylactic treatments.

Release strategies
Task 1.6: Develop release strategies that will increase survival to adulthood for hatchery-reared spring chinook salmon.

- Evaluate condition of spring chinook salmon prior to release. Evaluate smolt quality, degree of smoltification, sexual precocity, organosomatic indices, and environmental factors at time of release.

Objective 2: Determine that actions taken under the Mid-Columbia Hatchery Program conserve the genetic integrity and long-term fitness of naturally spawning populations of spring chinook salmon in the Mid-Columbia Region.

Overall assessment
Task 2.1: Determine the relative reproductive success of hatchery and natural fish in the natural environment by using DNA profiling of individual parents and progeny to reconstruct pedigrees. These data could also be used to estimate other important parameters such as effective population size, the reproductive success of different age classes, the degree of assortive mating, wild stray rates, and heritabilities and genetic correlations in the natural environment. More information on this task is provided in Appendix K.

Broodstock collection
Task 2.2: Develop, or revise an adult broodstock collection, passage, and spawning protocol.

- Ensure that collection is consistent with guidelines specified in annual protocol.

- Modify collection protocol in-season as appropriate, based upon analysis of run size, timing, and trap efficiency. Document rationale for modification, and results of that action.

Task 2.3: Document characteristics of donor population, to ensure that representative broodstock is collected.

- Monitor timing, duration, composition and magnitude of the spring chinook salmon run. Compare demographics of collected broodstock with the run at large.

Spawning practices
Task 2.4: Identify origins of spring chinook salmon adults at Mid-Columbia hatcheries during spawning to maintain phenotypic and genotypic characteristics of these populations.

- Extract and read CWTs of all marked chinook salmon at Mid-Columbia hatcheries during spawning, to determine incidence of stray salmon in hatchery broodstock.

- Determine what proportion of strays is acceptable. Develop strategy for management of strays.

<u>Task 2.5:</u> Collect baseline population profile data on nominal populations of spring chinook salmon.

- Sample adult salmon at the hatchery and the spawning grounds for scales, and genetics data (electrophoresis and possible DNA analyses).

- Take lengths and weights of returning adults, and determine sex ratios and age distributions. Compare fecundity of natural and hatchery females.

- Evaluate genetic characteristics, effective breeding population size, and risk of extinction for spring chinook salmon propagated at one or more facilities, and compare with those populations selected as non-intervention reference groups.

- Develop proper sampling and archival methods for future DNA analyses.

<u>Task 2.6:</u> Document mating and fertilization practices in hatchery.

- Record contribution of gametes by each fish spawned, and mating strategy that was used.

- Determine if different fertilization rates occur under various mating strategies.

- Correlate genetic and demographic data of the mated parents with that of their offspring.

<u>Task 2.7:</u> Develop means to increase effective breeding size and hatchery management options. Evaluate and improve gamete fertilization, storage, and extension techniques.

- Conduct fertilization and cryopreservation experiments to improve techniques.

- Cryopreserve milt of chinook salmon adults for future use.

Incubation practices
<u>Task 2.8:</u> Correlate emergence timing with natural environment, and investigate means to mimic natural incubation.

Rearing practices
<u>Task 2.9:</u> Test and evaluate rearing procedures to produce fish that are behaviorally and physiologically adapted to the river.

- Investigate feasibility of installing habitat structures in selected raceways, and/or modifying rearing practices. Evaluate response (growth, microhabitat use, behavior, disease incidence), and compare to control raceways.

- Modify feeding practices in selected raceways to include or mimic natural food and feeding characteristics. Evaluate response, and compare to control raceways.

Natural productivity

Task 2.10: Determine if hatchery salmon are similar to natural salmon in spawning characteristics.

- Compare fish behavior, and distribution of natural and hatchery salmon on the spawning grounds.

- Determine prespawning survival and egg retention of marked and unmarked fish in the donor population by examining spawners in the river.

Task 2.11: Compare survival rates among various life stages for spring chinook salmon in a natural river environment. Quantify freshwater survival rates, parr production, and rearing densities of a selected population of spring chinook salmon.

- Document adult populations of naturally spawning spring chinook salmon. Conduct redd counts, determine spawner density and escapement, and locations of preferred holding and spawning areas.

- Determine parr production and habitat use in a natural river environment through snorkel surveys.

- Determine standing crop and carrying capacity using snorkel and smolt trap data collected.

- Compare survival rates among life stages for spring chinook salmon in a natural river environment.

Task 2.12: Characterize and quantify natural spring chinook salmon juvenile outmigration from a natural environment.

- Determine magnitude, duration, and peak period of migration of natural spring chinook salmon smolts.

- Evaluate juvenile salmon migrational characteristics in relation to physical stream factors (flow, temperature, turbidity) and environmental factors (precipitation, photoperiod, barometric pressure, ambient light).

- Document natural smolt health through such indices as condition factor, fin condition, descaling and organosomatic indices.

Objective 3: Determine if salmon released from Mid-Columbia hatcheries interact adversely with natural productivity in the streams.

Release strategies
Task 3.1: Develop hatchery smolt release strategies that result in rapid outmigration, high downstream passage survivals, and have negligible impact on natural productivity.

- Evaluate volitional release strategies, and improve techniques.

- Determine the quantity and migration timing of hatchery smolts, and compare to natural salmon outmigration patterns.

- Evaluate interactions between natural and hatchery fish.

- Monitor migration timing, migration rates, and relative recapture rates of marked hatchery spring chinook salmon smolts at juvenile collection facilities at Rock Island and McNary dams by retrieving data collected under existing programs.

- Design hatchery release strategies that result in spawner distribution that resembles natural salmon.

Task 3.2: Evaluate the feasibility of spring chinook salmon outplants in selected streams.

- Identify potential sites for natural acclimation and release into underseeded areas.

- Develop appropriate strategy to compare releases from a single acclimation pond versus multiple release sites. Comparison should include migration timing and relative survival.

3.8.2: Juvenile-based captive rearing

The evaluation plan for the captive rearing component centers on the issues of genetic maintenance and the viability of captive-reared fish relative to fish propagated through adult-based supplementation. Most of this work will be done by comparing survival rates at selected life stages and phenotypic characteristics of the fish reared in captivity versus those reared in both the adult-based supplementation and the natural environment. Specific issues to be addressed in the evaluation plan include: (1) whether the facilities are capable of meeting production objectives, (2) an ability of the programs to meet established performance criteria, (3) the effects of egg/alevin extraction on the survival of the remaining eggs in the redds that were sampled for captive rearing, (4) a comparison of within- and among-family survival rates of fish held in captivity, (5) morphometric and meristic analyses of fish held in captivity versus those in natural environment, and (6) the ability of captive-reared fish to spawn in the natural environment.

(1) Facility capability

At this time, it has not been determined what specific locations and infrastructure are required to captive rear the three selected nominal populations (White River, Nason Creek, and Twisp River). However, the HWG recognized that facilities in addition to those currently in the Mid-Columbia Region will be required--particularly for the Twisp River program (although some existing facilities, such as Chiwawa FH, may be simultaneously used for supplementation and some captive rearing). These sites must be capable of rearing four sequential brood years at numbers identified in Table 19 at specified facility standards. These standards have not been developed at this time, but the HWG assumed they will be comparable to other anadromous salmonid captive rearing programs in the Pacific Northwest (Flagg and Mahnken [1995] provide a current assessment of the status of captive broodstock facility standards). Some populations (such as Dungeness spring chinook salmon) are reared in two locations (one in freshwater and the other in saltwater), both to reduce the risk of complete loss of the broodstock due to site-specific mortality and to allow one to assess the relative merits of the two different approaches (Shaklee et al. 1995). The Mid-Columbia Hatchery Coordinating Committee will develop the appropriate facility requirements and standards, then annually review the capability of the facilities to meet the agreed standards.

(2) Performance criteria

To be considered successful, the captive rearing program must have a two-fold increase in adult returns in two generations (one full rearing cycle) over the adult-based supplementation program. The overall success of the captive rearing program cannot be determined until adults return from the program (a minimum of 8 years after the captive rearing begins), but several interim checks could be used to provide preliminary indications of program success. These checks would form threshold criteria (Table 21) to assess the benefit of the captive rearing program during their early stages of implementation.

The HWG established a production benefit rate of 2 for juvenile-based captive rearing, relative to adult-based supplementation (in other words, captive rearing programs must yield two times the adults as adult-based supplementation programs to be successful). This standard is based upon the approximate product of the observed values for each life stage (Table 22), and must apply to half the brood years that are propagated. If the captive rearing program is operating below minimum threshold values for two or more criteria, it will fail to meet this rate, unless the other values exceed the expected criteria. The Mid-Columbia Hatchery Coordinating Committee will annually review the captive rearing programs for success in meeting the production benefit rate of 2. If the individual values are at minimum threshold, indicating that it is mathematically improbable that the overall production rate will be met, the Mid-Columbia Hatchery Coordinating Committee may elect to (1) change the hatchery production of Wenatchee River spring chinook salmon to an adult-based supplementation program, based on adult broodstock collections at Tumwater Dam, or (2) modify the captive rearing program to improve its performance. These values will be determined yearly, but actions to change or modify the program will be done only after two brood years have been collected.

Table 21. Expected performance criteria for adult-based supplementation and captive rearing programs, and minimum threshold criteria for juvenile based captive rearing program.

Criterion	Adult-based supplementation expected performance	Juvenile-based captive rearing	
		Expected performance	Minimum threshold
Natural fecundity	4,400		
Captive fecundity		2,000	1,000
Natural female:male ratio	1.0:1.0		
Captive female:male ratio		1.0:1.0	0.5:1.0
Egg-release survival[1]	0.8 smolts/egg	0.8 smolts/egg	0.4 smolts/egg
Release-adult survival[2]	0.003 adults/smolt	0.003 adults/smolt	0.0015 adults/smolt
Captive egg-adult survival		0.3 adults/egg	0.15 adults/egg

[1] *The egg-release survival is the performance standard for yearling chinook salmon at Mid-Columbia hatcheries (Appendix F).*

[2] *Many HWG members did not feel the 0.003 adults/smolt value for hatchery released spring chinook salmon (Table 3) was appropriate, and suggested that the minimum threshold criterion should be half that of the running five-year average value in the Mid-Columbia supplementation programs*.

(3) Effects of egg extraction

Based on logistical and genetic considerations, the preferred approach is to use captive broodstock derived from wild eggs and fry to provide large numbers of progeny for future release into the river while allowing continued natural production. Based on experience elsewhere, the least risk method to collect the eggs and fry is hydraulic pumping of redds augmented by electroshocking of post-emergent fry (Young and Marlowe 1996). Shaklee et al. (1995) felt hydraulic sampling was an effective method of collecting pre-emergent fry, although they were concerned about the deleterious effects of on the survival of fry remaining in the redds. At this time, the HWG was not able to create a study plan to evaluate the effects of hydraulic pumping on the remaining fry, but the Mid-Columbia Hatchery Coordinating Committee will investigate means to assess this as the programs develop.

(4) Within and among-family survival

Inbreeding depression is an important concern in captive broodstock programs for threatened or endangered fish because it addresses the additional risk of extinction that results when related individuals are mated (Hard and Hershberger 1995). The experimental design to determine the genetic consequences of inbreeding will have two approaches: (1) examine the variation in family size as an indicator, (2) or examine the physical characteristics of families of various known pedigrees. To date, the HWG has not developed a study plan to address this issue. At a minimum, full-sib fish groups will be given a unique mark to allow recognition of each family's contribution.

Table 22. Comparison of production potentials for juvenile-based captive rearing and adult-based supplementation, based on minimum threshold criteria for captive rearing. Both intervention strategies are based on an initial source of 5,000 eggs, enabling a direct comparison of the two. If the value at each criterion is at the expected performance standard, the production benefit rate for captive rearing is ~56 (3,600 divided by 64); if all values are at minimum threshold, the production benefit rate for captive rearing is ~2.4 (150 divided by 64). Values for each criteria are in Table 19. A value larger than 2.4 for half or more of the brood years would indicate overall success of captive rearing.

Performance criterion for each life stage		Intervention strategy			
		Juvenile-based captive rearing			
Expected performance criteria					
Eggs →	Adults →	Eggs →	Smolts →	Adults →	Benefit
5,000	1,500	1,500,000	1,200,000	3,600	56
Minimum threshold criteria					
Eggs →	Adults →	Eggs →	Smolts →	Adults →	Benefit
5,000	750	250,000	100,000	150	2.4
		Adult-based supplementation			
Eggs →	Adults →	Eggs →	Smolts →	Adults →	Benefit
5,000	12	26,400	21,120	64	1

(5) Physical characteristics

Several studies have examined the quantitative basis of life-history characteristics and their covariation with morphological and other characters (Leary et al. 1985; Johnsson et al. 1993; Hard 1995). The HWG felt these measurements may indicate a potential problem in changes to the artificially reared population. Such problems include, but are not limited to inappropriate spawn timing, changes in age structure, fecundity, and fertility, and sex ratio of the propagated population. To date, the HWG has not developed a study plan to address this issue. The Mid-Columbia Hatchery Coordinating Committee will monitor these characteristics so that significant changes to the propagated population may be detected in a timely manner.

(6) Ability to spawn naturally

The HWG is concerned about the potential for genetic divergence of the captively-reared fish from their natural source population, and the subsequent genetic consequences of matings between these two groups. To date, the HWG has not developed a study plan to address this issue. At a minimum, this effect will be generally addressed in the long-term evaluation of the effects of supplementation (Section 3.7.1).

SECTION 4: STEELHEAD

4.1: Background

As stated in Section 1.3, the HWG determined that some form of hatchery-based intervention will be necessary to achieve population recovery. The least risk alternative for recovery of steelhead must include fostering local adaptation of tributary populations at least at the watershed level (the Wenatchee, Entiat, Methow, and Okanogan watersheds). The HWG felt the most rational approach to steelhead recovery, given the current circumstances, include a combination of measures directed at promoting local adaptation, improving our knowledge of natural populations, reducing the rate of residualism for hatchery fish, returning natural steelhead to upper tributary spawning areas now under seeded, and opening new habitat.

From 1964 to 1983, steelhead broodstock were obtained at Priest Rapids Dam, which were propagated at Chelan FH. From 1984 through 1995, broodstock for the steelhead production throughout the entire Mid-Columbia Region was derived from Wells Dam and FH. WDFW initiated changes in mitigation hatchery steelhead production in 1996, which re-directed artificial production programs toward development of locally adapted broodstocks and improvement in the perceived fitness of the Wells FH population.

4.2: Management Assessment

As part of the Wells Settlement Agreement, Wells FH is to produce 480,000 steelhead smolts (80,000 lbs at about 6 fpp) for scatter plants in the Methow River (up to 380,000), the lower Similkameen River (50,000) and up to 50,000 in the Okanogan River and tributaries. Natural and hatchery steelhead are collected at the west ladder of Wells Dam and as volunteers to Wells FH for broodstock. Collections at Wells Dam and FH have provided steelhead to various locations, including Winthrop NFH, Chelan Falls FH, Eastbank FH, and at times, to Ringold Springs FH. Adult steelhead retained at Wells Dam and FH for broodstock are selected by proportional return time (i.e., 20% August returns, 30% September returns, etc.). Steelhead are spawned at the hatchery from January through early March. In comparison, wild fish spawn in the rivers from March through May. An average of 7.5% of the females spawned at Wells FH are wild fish (Wold 1993), which are mostly toward the end of spawning. In addition, Winthrop NFH rears an additional 100,000 Wells stock steelhead smolts for release into the Methow River at Winthrop. A description of the Wells FH and Winthrop NFH facilities is in Section 3.2.

Constructed near the turn of the century, Chelan FH was expanded in 1964/65. The expanded portion operates to compensate for losses incurred as a result of Rocky Reach Dam. It is located near the confluence of Chelan River and the Columbia River, about 20 km downstream of Wells Dam. The facility has 80 troughs, eight intermediate raceways, 16 main raceways, and one adult holding pond. From 1983 to 1997, steelhead were spawned and incubated at Wells FH, and transferred at the eyed stage to Chelan FH. The steelhead are reared there until fall, then are transferred to Turtle Rock for final rearing on Columbia River water. Beginning in 1997, the Chelan/Turtle Rock steelhead program is sourced from local broodstock captured in the Wenatchee River. The current production objective is to scatter plant 160,000 summer steelhead (26,700 lbs at about 6 fpp) into areas of the Wenatchee River downstream of Tumwater Dam, and to scatter plant 40,000 steelhead (6,700 lbs at about 6 fpp) into areas of the Entiat River. The hatchery also produces 200,000 legal sized rainbow trout, 70,000 cutthroat trout, and up to 1,500,000 kokanee fry. Resident fish are released at various locations outside of waters accessible to anadromous salmonids.

As part of the Rock Island Settlement, Eastbank FH rears 200,000 smolts for scatter releases into the Wenatchee River. Wells FH has provided the donor population since the program began in 1989, but in 1995 the program began collections of Wenatchee River broodstock. The hatchery uses mechanically chilled water to retard early embryonic development, thereby meeting the planting size of 6.5 fpp. A description of Eastbank FH facilities is in Section 3.2.

NMFS (Busby et al. 1996) identified the summer steelhead in the Columbia River upstream of the Yakima River as a separate ESU, and were strongly influenced by the GCFMP (Section 1.6.1). The extent of the population mixing from this action are not totally understood. The total abundance of populations within this ESU has been relatively stable, yet this is because of a large component of hatchery fish in the adult returns. Busby et al. (1996) estimated the proportion of hatchery fish in spawning escapement to be 65% in the Wenatchee River and 81% in the Methow and Okanogan rivers. Recent 5-year (1989-1993) average natural escapement estimates are 800 steelhead in the Wenatchee, and 450 steelhead in the Methow and Okanogan rivers. The major concern for this ESU is the clear failure of the natural component to replace themselves. WDFW estimated Natural Cohort Replacement Rates of 0.3 in the Wenatchee River and 0.25 in the Entiat River (Brown, WDFW, pers. comm.). WDF et al. (1993a) suggested that the original Okanogan population may be extinct, with the possible exception of resident morphs in Salmon and Omak creeks.

4.3: Genetic Assessment

Busby et al. (1996) outlined the impacts of homogenization of steelhead from the three streams (Wenatchee, Methow, and Okanogan) from the use of a single broodstock source (Wells FH). The hatchery fish were originally derived from indigenous populations intercepted during the GCFMP. The current population was initially developed in the early 1960s from naturally spawning populations intercepted at fish passage facilities at Priest Rapids Dam and since 1970, from steelhead trapped at Wells Dam. Wells steelhead have been distributed in the Columbia Basin from the Big White Salmon River to the Grande Ronde River.

Based upon electrophoretic analysis of steelhead collected at Wells FH and in the Wenatchee River, Phelps (WDFW, pers. comm.) suggested that steelhead within the Mid-Columbia Region probably belong to one GDU, although their relation to resident forms is not understood. The HWG used this recommendation, and analyses of spawner distribution and abundance, to suggest a demographic/ ecologic grouping of steelhead within this region (Appendix E). The HWG used this grouping as a framework for developing a hatchery program to encourage local adaptation to these differing ecologic conditions.

4.4: Ecologic Assessment

In general, steelhead adults migrate into the mid-Columbia River tributaries in both fall and spring after spending one to three years in the ocean (Wydoski and Whitney 1979). Most upper Columbia steelhead spend only one or two years in the ocean (Brown, WDFW pers. comm.). Spawning occurs primarily in May, but may extend much later. Their eggs incubate from late March through July, and fry emerge in early summer to September. Fry and smolts disperse downstream in late summer and fall. Their use of tributaries for rearing is variable, depending upon population size, and both weather and flow conditions at any given time. Smolts typically leave the Columbia River tributaries in March to early June, after spending one to seven years in freshwater, but most leave after two to three years (Peven et al. 1994). Some steelhead have progeny that live their entire lives in freshwater. Historically, some steelhead spawned repeatedly over several years (making repeated migrations to and from the ocean), but this strategy may have been reduced by hydroelectric dams on the mainstem Columbia River. As a result of their varied length of fresh water residence, their variable ocean residence, and their spatial and temporal spawning distribution within a watershed, steelhead exhibit an extremely complex mosaic of life history types (Withler 1966, Peven et al. 1994). In the mid-Columbia Region, steelhead smolts may be susceptible to high harvest rates in rainbow trout fisheries, and the degradation of freshwater habitats within the region, especially the effects of irrigation diversions, flood plain loss, and stream channelization (Bugert et al. 1997a).

4.5: Risk Assessment

The degree that first and second generation hatchery fish can reproduce successfully in the natural environment is a critically unanswered question. Not only does the answer to this question determine how successful the Mid-Columbia Hatchery Program can be in speeding the recovery of the Upper Columbia steelhead ESU, it also has a direct bearing on determining the degree of extinction risk faced by this ESU (Schiewe 1997, p. 28). Briefly, one of the chief factors indicating that this ESU is at risk is its very low natural cohort replacement rate (Busby 1996), which Brown (1995) estimated to be ~0.3. This statistic is difficult to interpret however, because a large proportion (65% - 85%) of the natural spawners are hatchery fish (Brown 1995). If one assumes that naturally spawning hatchery fish are equally productive as naturally spawning wild fish, then this low natural replacement rate indicates that the natural population is falling far short of replacing itself and the presence of naturally spawning hatchery fish may be slowing its decline or even keeping it from going extinct. On the other hand, if the hatchery fish have limited productivity in the wild, a natural replacement rate of 0.3 combined with 65% naturally spawning hatchery fish would indicate that in fact the natural component of the natural spawners is probably replacing itself (Schiewe 1997, p. 28). Under this scenario, the presence of hatchery fish on the spawning grounds might actually be impeding recovery. The HWG believes the true situation is almost certainly somewhere between these two extremes, and determining the degree that naturally spawning hatchery fish successfully reproduce in the wild is critical.

Although the Wells FH population has been deemed essential for recovery (Schiewe 1997), there may be some risks associated with its use. In particular, based on the data in Brown (1995) and information provided in WDFW (1997), it appears that there may be genetic differences in life history traits between the Wells FH stock hatchery steelhead and natural steelhead. If this is the case, supplementation with this population may not be effective in assisting recovery efforts. Because of this uncertainty, determining the degree that Wells FH stock fish successfully reproduce in the wild is critical.

4.6: Wenatchee River

4.6.1: Escapement goal and production capacity

The recommended escapement by NPPC subbasin plans for the Wenatchee River is 3,000 wild/natural steelhead. Past run-size information (Chapman et al. 1994b) tends to support a goal of this magnitude. Mullan et al. (1992) calculated an MSY-based steelhead escapement goal of 2,275 fish for the Wenatchee Basin. WDFW parr production models predict a habitat capacity of 62,167 (GAFM2 model) to 100,000 (original GAFM model) steelhead smolts. Using these capacity estimates, replacement of natural spawning should occur at approximately 3.4% smolt to adult survival, yielding adult replacement run sizes of 2,108 to 3,400 steelhead, depending on the model assumptions.

The immediate emphasis for rebuilding the Wenatchee steelhead population will be to redirect the current level of hatchery production into a recovery supplementation program based on a locally adapted broodstock. Rarely, if at all, would this program return to using Wells FH stock.

4.6.2: Phase A production objective

Locally adapted, adult-based supplementation will be considered a "prototype" recovery program for the Wenatchee River. The program size will remain at the present 360,000 smolt level which, under current constraints, should maintain an adult return of 3,600 adults at 1% survival. The initial broodstock target for the Wenatchee hatchery program will be 100 wild/natural and 128 hatchery fish (Wells lineage). Broodstock will be collected at Dryden and Tumwater dams. Some modifications may be necessary at each facility to make them more effective at steelhead capture. Obtaining the target numbers of wild adults may be problematic because of facility constraints (low effectiveness in trapping broodstock at Dryden Dam). Hook and line capture of unmarked fish by qualified anglers may be used to supplement broodstock collections if the traps are not effective. Broodstock will be held and spawned at Eastbank FH; progeny will be reared both at Chelan/Turtle Rock and Eastbank. All steelhead released to the Wenatchee River will be given an external mark unique to that stream and brood year.

The preferred strategy for spawning at Eastbank FH within a given year will be developed within the annual broodstock protocol for that program. The general objective will be to maximize HxW crosses to the extent possible to make the fullest use of hatchery fish and most complete inclusion of locally adapted traits into a single population for the rebuilding process. The highest quality and/or most genetically desirable (HxW or WxW) smolts will be scatter planted into the best available spawning and rearing habitats. These will promote adult spawning distributions which take advantage of natural production. The specific release strategy to be used will depend on an assessment of relative risks of each. Truck releases will be used initially, but that process may be changed in favor of using acclimation sites as they may be developed. During Phase A of the Mid-Columbia Hatchery Program, an evaluation of the relative merits of acclimation and scatter releases for steelhead will be done. Phase B will use one or both of these strategies, depending upon these ongoing evaluations.

An important component of the steelhead hatchery evaluations for the Wenatchee River would be an analysis of the influence of rearing water temperature on parr/smolt transformation. The hypothesis to be tested is that hatchery-reared steelhead overwintered on river water have lower precocity and residualism rates than steelhead reared entirely on well water. An understanding of the effects of rearing conditions on the parr/smolt transformation process will improve the managers' capability to reduce the rates of precocity in hatchery-reared steelhead.

4.7: Entiat River

4.7.1: Escapement goal and production capacity

There is no official or legally defined escapement goal for the Entiat River at this time. Mullan et al. (1992) calculated an MSY-based escapement goal of 417 fish for the Entiat River. The WDFW GAFM2 parr production model estimates a production potential of 12,739 smolts. Replacement of natural spawning should occur at 3.4% smolt to adult survival, yielding an adult replacement run size of 442 steelhead from the estimated potential production level.

4.7.2: Phase A production objective

The current hatchery smolt program is 40,000 smolts, based upon adults collected at Wells FH, which should return about 400 adults at a 1% hatchery smolt to adult survival rate. The preferred strategy is to maintain the present hatchery production program using Wells stock for the Entiat River in the short term while a supplementation strategy is developed for the Entiat River. Based upon an initial production rate of 40,000 smolts, about ~~50~~ 30 adults will be required. In Phase A of the Mid-Columbia Hatchery Program, a terminal area trap will be developed on the Entiat River to collect, among other species, steelhead. The program will collect very few natural steelhead (less than 20) in the initial years to incorporate into the supplementation program for that river; the balance of the broodstock source ~~(30 fish)~~ will remain marked Wells FH steelhead. Hook and line capture of unmarked fish by qualified anglers may be used to supplement broodstock collections if the trap is not effective, or prior to trap development. In Phase B, production levels will increase to meet natural fish escapement goals, based upon the development of a local Entiat River broodstock, or, if juvenile based abundance levels of Entiat River steelhead indicate a Natural Cohort Replacement Rate of 1.0 or greater.

Spawning, incubation, and initial rearing, will be at Eastbank FH. Final rearing will be done at a facility related to Entiat NFH. In Phase A, sites will be evaluated for potential acclimation of steelhead in the Entiat River upstream of the hatchery. Releases will be predominantly scatter plant. Steelhead may be acclimated to a site on the upper Entiat River in Phase B, if results from the Methow River acclimation experiment indicate that this strategy reduces impacts to natural steelhead. If acclimation sites are developed on the Entiat River, it would be used in conjunction with acclimation for spring chinook salmon (Section 3).

A study may be undertaken on the Entiat River to evaluate the degree of residualism in scatter planted or acclimated released steelhead, and their interactions with naturally produced salmonids. Parameters to be assessed will include displacement, predation, cannibalism, relation of release size to residualism rates.

The HWG agreed on the importance of selecting one steelhead population as a non-intervention "reference" group to assess the reproductive success of a natural population not being supplemented through artificial propagation, and selected the Entiat River as the most appropriate population to assess this. However, the HWG recognized the logistical difficulties of estimating natural population abundance, at several age classes, in that watershed. Nevertheless, the HWG wishes to continue discussions on developing a means to study the Entiat River steelhead population as a non-intervention population. If the HWG decides to eliminate artificial propagation in the Entiat River, the production objectives in Phase A for that river will be shifted to the Wenatchee River.

4.8: Methow River

4.8.1: Escapement goal and production capacity

Mullan et al. (1992) calculated an MSY-based escapement goal of 2,212 fish for the Methow River. The WDFW GAFM parr production model estimates a production potential of 58,552 smolts. Replacement of natural spawning should occur at 3.4% smolt to adult survival, yielding an adult replacement run size of 1,990 steelhead from the estimated potential production level. The recommended escapement objective by the NPPC subbasin plan for the Methow River is 1,500 wild/natural steelhead. Adult returns from the current programs (assuming 1% survival) are expected to be 4,500 adults to the Methow River and 1,000 adults to the Okanogan River.

4.8.2: Phase A production objective

The preferred alternative for the near-term future is to maintain the present hatchery production program using Wells stock for the Methow and Okanogan rivers while a means to collect marked and unmarked steelhead on the Methow River is tested. This project will be done in conjunction with similar activities for summer chinook salmon in the Methow River. Hook and line capture of unmarked fish by qualified anglers may be used to supplement Methow River broodstock collections. Like the process to develop a local broodstock for the Entiat River, this process will be done on a gradual basis (8 to 10 years), to lessen impacts of broodstock collection on natural production. In the long term, assuming wild fish characteristics are established, and proper escapement goals are in place, a fully developed local broodstock will be the preferred strategy for Methow River supplementation.

An existing acclimation site would be used (or a new site would be developed) to evaluate the relative effects of acclimation and scatter planting on hatchery effectiveness. Parameters to be assessed will include residualism, homing, and release to adult survival. Moreover, a study is underway to determine if hatchery steelhead survival increases with infusion of wild parents into the broodstock.

4.9: Okanogan River

4.9.1: Escapement goal and production capacity

Currently, no agreed to wild/natural escapement goal for Okanogan River steelhead exists. Using available information and the WDFW GAFM2 parr production model, the CCT has estimated the potential smolt production in the Okanogan Basin at 17,570 smolts. This estimate does not include potential production in the Similkameen River above Enloe Dam. Replacement of natural spawning should occur at 3.4% smolt to adult survival, thus producing an adult replacement run size of 597 steelhead.

4.9.2: Phase A production objective

The preferred strategy is to shift a portion of the current hatchery production into a supplementation recovery effort designed to develop and use locally adapted broodstock. Initially this strategy will require broodstock collections to continue at Wells Dam. However, tributary collection sites will be identified and developed on Omak and Salmon creeks, when possible. Hook and line capture of unmarked fish by qualified anglers may be used to supplement broodstock collections if the traps are not effective, or prior to trap development.

The initial Okanogan River steelhead hatchery production program will require a broodstock predominantly comprised of Wells FH stock. The current program size of 100,000 smolts will remain in place and should provide an adult return of 500 to 1,000 adults to the Okanogan River. Broodstock and spawning protocols will be required for this program, based on an assessment of risk to the natural population. Spawning, incubation, and initial rearing will be conducted at Wells FH. However, some adjustments will be required for culturing the natural fish.

In Phase B, outplants to Omak Creek and Salmon Creek will consist of the most genetically suitable smolts (WxW and WxH) of an adequate number to meet natural production capabilities. Acclimation sites may be required, but initially trucked releases will be used. Additional smolts will be scatter planted into the Okanogan and lower Similkameen rivers.

4.10: Monitoring and Evaluation

Steelhead in the Mid-Columbia Region are considered to be at high risk of extinction (Busby et al. 1996). The HWG determined that hatchery supplementation presents an appropriate strategy to recover these populations. In addition, the HWG felt that a transition from a single broodstock source to several locally adapted sources may improve the likelihood of recovery of these populations. However, a rapid transition from a single source to multiple sources may initially lessen hatchery production, and ultimately, natural escapement. This transition in itself poses some risk to the natural population. A well-defined evaluation plan for this transition is required to ensure that impacts to the natural population is minimized. Emphasis in the evaluations will be placed on the following issues: (1) does development of a local broodstock improve overall performance of hatchery released steelhead, (2) can residualism be controlled through various cultural techniques, (3) does acclimation differ from scatter plants in reducing impacts upon natural production, (4) do the hatcheries collect an appropriate sample of both natural and hatchery fish, and (5) what are the Natural Cohort Replacement Rates for selected supplemented populations in the region? The following outlines the general strategy of the evaluations to meet these objectives:

(1) Implement a data base management system at each facility.

a. Broodstock management:
   - run timing, percent of total run collected, representativeness of sample, trap operation, etc.,
   - wild/hatchery composition, and gamete allocation,
   - fecundity, sex ratios, age structure, time of spawning, etc., and
   - disposition of unspawned adults returned to the river.

b. Incubation and rearing:
   - distribution of gametes from Wells FH to other stations,
   - survival through selected life stages, correlated with cultural strategies,
   - feed use, conversions, and
   - density indices, water use, etc.

c. Formal reporting of fish health maintenance procedures.

d. Record smolt or pre-smolt release information.

e. Summarize information on adult production.

f. Record tag and mark recaptures.

(2) Evaluate fish cultural operations at each facility.

a. Determine survival of hatchery steelhead from release to adult return.
   - release similar-sized steelhead reared at each hatchery. The fish will have external marks unique to that facility.
   - Recover marked adults intercepted at Priest Rapids Dam (and Wells Dam if required) for comparison of survival rates.

   Nested within this comparison could be an evaluation of fish cultural strategies (Objective 1), reproductive potential (Objective 3), and volitional release strategies (Objective 5). The extent of these tests would depend upon required sample sizes, hatchery programming, and an assignment of priorities in evaluations.

b. Determine the efficacy of predator control devices at Wells FH.

c. Examine feasibility of alternative culture strategies:
   - programmed release sizes for progeny of late-spawning steelhead
   - accelerated smolts
   - use of chilled water at Eastbank
   - use of vertical incubators at Eastbank
   - use of alternative rearing containers at Eastbank.

(3) Estimate reproductive potential of hatchery and natural steelhead in the river.

a. Estimate hatchery smolt outmigration derived through Rock Island bypass sampler, and compare with estimates of adult returns, measured at Priest Rapids and Wells dams.

b. Determine feasibility of sampling natural smolts at Dryden canal bypass and adult sampling at Dryden Dam (done in conjunction with Objective 4).

c. Develop spawner/recruit relationships for hatchery (and if possible, natural) steelhead, based upon these data.

d. Evaluate estimates of full seeding for all tributaries.

(4) Assess the need to develop local broodstock, particularly on the Wenatchee River.

a. Monitor incidence of unmarked adult steelhead during salmon trap operations at Dryden, Tumwater, and Chiwawa facilities:

- assemble data on run timing and trap efficiency, and
- if needed, live sample the trapped steelhead for genetic and demographic analyses. Compare with existing data.
- reconcile these data with information gained from Objective 6.

b. Assess feasibility of propagating progeny of steelhead collected on the Wenatchee River at Eastbank (or another) hatchery:
   - determine production required to evaluate this strategy, and
   - reconcile these plans with Objective 2.

(5) Monitor steelhead preparedness to migrate downstream at time of release.

a. Evaluate volitional emigration from existing rearing ponds:
   - determine feasibility of installing/modifying volitional release structures at Eastbank, Turtle Rock, and/or Chelan hatcheries--make them compatible with the facility at Wells FH,
   - do biological sampling (parr/smolt transformation, sexual precocity, lengths, etc.) of both emigrating and remaining steelhead at Wells FH, and other facilities, if possible,
   - determine feasibility of comparing adult returns (measured at Priest Rapids Dam) of actively emigrating steelhead versus a forced release of those that remain in ponds. Determine if the experimental design for such a comparison would conflict with Objective 1.
   - determine best strategy for use of remaining steelhead (release as anadromous fish versus resident fish in landlocked system).

b. Acclimated releases versus scatter plants:
   - determine feasibility of using and evaluating salmon acclimation pond(s) for steelhead, and determine if experimental design for such a comparison would conflict with Objective 1, and if required,
   - develop strategy for future broods.

(6) Determine if the natural steelhead in the mid-Columbia tributaries genetically different from those produced in the hatcheries.

a. Compile and analyze existing data base on mid-Columbia steelhead genetics.

b. Collect steelhead/rainbow juveniles in selected tributaries (probably Chiwawa and Chewuch rivers, and possibly Entiat River) and compare with existing data.

c. Monitor incidence of unmarked adult steelhead during salmon trap operations at Chewuch, Twisp, and (if possible) Foghorn facilities:
   - assemble data on run timing and natural/hatchery composition, and
   - if needed, live sample the trapped steelhead for genetic and demographic analyses. Compare with existing data.

d. Determine need for alternative sampling and analysis.

(7) Determine the most effective allocation of production in a year of low adult returns (less than full seeding of habitat and broodstock collection requirements).

a. Develop annual broodstock collection protocol, based upon information gained in objectives 3, 4, and 6.

b. Reprogram Wells and Eastbank hatcheries, if necessary, to optimize balance of salmon and steelhead production plans.

SECTION 5: SOCKEYE SALMON

5.1: Background

The interim No Net Impact hatchery production objective for sockeye salmon under the Mid-Columbia Hatchery Program is 1,443,000 yearling smolts at 20 fpp (72,150 lbs.). Production is to be split between the Okanogan and Wenatchee populations, at or near 1,000,000 and 443,000 smolts respectively, because of differential passage mortalities between the two. Meeting this objective will be difficult because of logistical and political constraints (these are addressed in sections 5.5 and 5.6). In Phase A of the Mid-Columbia Hatchery Program, production will be based upon those strategies that are not constrained. Phase B production will begin when these constraints are resolved. Production levels during Phase B may not necessarily be 1,443,000 however, because of the floating 7% hatchery production objective under variable escapement rates (see Section 1.4).

Wenatchee sockeye salmon

Since 1989, the RIHC operates a sockeye salmon supplementation program for the White and Little Wenatchee rivers. Natural fish are collected from the run at large; 300 are required for broodstock, which typically comprises about 1% of the total run. Sockeye salmon are reared in six floating net pens on Lake Wenatchee. The pens are located on the west end of the lake near the mouths of Little Wenatchee and White rivers. Two additional net pens are used for holding adult salmon; these are located adjacent to the rearing pens. Program production goals are for 200,000 fish released in fall at 20 fpp (Appendix F). Preliminary smolt-to-adult survival rates for this program are 0.7% (Table 4), although this is based upon few brood years. Fall releases of sockeye salmon pre-smolts from Leavenworth NFH into Lake Wenatchee in the 1960s had average survival of 0.67% (Mullan, 1986).

Sockeye salmon broodstock are collected at Tumwater Dam, located at RK 53 on the Wenatchee River. Adults are transported to the Lake Wenatchee net pens until maturity. Adults are spawned at 1:1 male to female ratio using two female and two male pools of gametes. Gametes are transported to Eastbank FH for fertilization and incubation. Fry are then returned to the net pen complex and reared until the fall, when they are released into the lake. Hatchery crews transfer 270,000 fry from Eastbank FH to the Lake Wenatchee net pens in April for rearing through release in October at 20 fpp. The hatchery fish reside in the lake for 6 to 8 months before migrating.

Okanogan sockeye salmon

Cassimer Bar FH is an experimental facility which began operation in 1992 to compensate for passage mortalities of sockeye salmon at Wells Dam. This facility is funded by Douglas PUD and operated by CCT. Sockeye salmon broodstock for Cassimer Bar FH is collected at Wells Dam east ladder and held in vinyl raceways at Cassimer Bar, which is at the confluence of the Okanogan and Columbia rivers. The facility uses well water to supply two 22 ft circulars, two 8 x 70 ft raceways, and incubation facilities. The objective of this pilot project is to produce 8,000 pounds at 25 fish per pound (200,000 fish), to be released in the spring as subyearlings from the nets pens in the lower basin of Lake Osoyoos (Appendix F). Adults are spawned at 1:1 male to female ratio.

5.2: Management Assessment

Production of Wenatchee sockeye salmon is primarily limited by oligotrophic conditions in Lake Wenatchee (the sole rearing lake). Lake Wenatchee is reported to be one of the least productive sockeye rearing lakes in North America (Allen and Meekin 1980), yet habitat and migration conditions are generally considered fair to good in this basin (Mullan 1986; Bugert et al. 1997a). The recent 5-year escapement for this ESU was about 26,000 adult sockeye salmon and the recent (1985-1994) abundance trend has been declining about 4% per year, with a single low abundance in 1994. The long-term (1961-1994) abundance trend for this ESU shows an increase of about 1% per year (BRT 1996). Wenatchee sockeye salmon spawn primarily in the White River and secondarily in the Little Wenatchee River (French and Wahle 1959; Wahle et al. 1979). Most sockeye salmon emigrate from Lake Wenatchee as smolts in spring (French and Wahle 1959; Mullan 1986). Competition for food may play a role in the mortality of juvenile sockeye (Mullan 1986). Predation also limits production of sockeye salmon (Beauchamp et al. 1995; Wahle et al. 1979; Thompson and Tufts 1967). Chapman et al. (1994b) suggest that the low productivity of Lake Wenatchee may increase the vulnerability of juvenile sockeye salmon to predation.

Production of Okanogan sockeye salmon is substantially limited by barriers to migration (McIntyre Dam on the Okanogan River, and Enloe Dam on the Similkameen River). The Okanogan sockeye salmon are vulnerable to channelization of the only remaining spawning habitat (the mainstem Okanogan River upstream of Lake Osoyoos), the summer high water temperatures that block migration of adults in the lower Okanogan River, and the nine hydropower dams on the Columbia River. The run size for this population has been highly variable over time, with recent 5-year average annual escapement at about 13,000. The recent (1985-1994) abundance has declined about 18-19% per year, although this is strongly influenced by high abundance in 1985 and low abundances in 1990 and 1994.

5.3: Genetic Assessment

The sockeye salmon BRT (1996) examined genetic, life history, biogeographic, geologic and environmental information in the process of identifying ESUs. Based upon this information, the BRT found those salmon from the Wenatchee and Okanogan rivers to be distinguishable. Important factors that distinguish the Wenatchee population from other Columbia River sockeye salmon included electrophoretic data that indicate this population is genetically the second most distinctive (after the Redfish Lake population) within the contiguous United States, and life history and environmental differences from the Okanogan population. The BRT concluded that sockeye salmon in this ESU are in not danger of extinction and are not likely to become endangered in the foreseeable future if present trends continue. Despite this conclusion, the BRT had concerns about the overall health of this ESU, including the effects of hydropower development in the Columbia River and the effects of hatchery production and potential interbreeding with non-native kokanee and resultant genetic integrity of this population.

The Okanogan population includes all sockeye salmon that spawn in areas upstream from Lake Osoyoos. The spawning and main rearing areas for this population are in British Columbia, while the migration corridor is in the United States. Important factors that distinguish this population as a separate ESU include: (1) the use of a very eutrophic lake-rearing environment (Lake Osoyoos), which is unusual for sockeye salmon, (2) the relatively large average smolt size of juvenile sockeye salmon in Lake Osoyoos, compared to other Columbia River sockeye salmon populations, (3) the tendency for a relatively large percentage of the Okanogan River sockeye salmon population to return as 3-year olds, (4) the juvenile run timing differences between Okanogan River and Wenatchee River fish, (5) the adaptation of Okanogan sockeye salmon to much higher water temperatures during adult migration in the Okanogan River, and (6) protein electrophoretic data that indicate that this population is genetically distinct from other sockeye salmon populations currently in the Columbia River.

5.4: Ecologic Assessment

The Mid-Columbia Hatchery Program places emphasis on release of sockeye salmon into areas of significant natural production. Because of this, deleterious ecological effects upon natural fish are of concern. Hatchery strategies that minimize risk to natural populations will be used. These strategies include, but are not limited to, acclimation on natal waters, and an assessment of the rearing capacity of the receiving lakes.

During both phases of the Mid-Columbia Hatchery Program, a significant portion (up to 10% in low return years) of the natural production will be trapped as the donor brood to initiate the additional hatchery production. Efforts to minimize the deleterious impacts to the natural production may be required. An approved broodstock collection protocol will be required before initiation of the additional production programs.

Two different production strategies will be considered for the Mid-Columbia Hatchery Program for sockeye salmon. One is to use programs based on the supplementation concept, the other is to artificially propagate fish outside the natural production watersheds that are not intended to interact with the natural populations. The goal of supplementation concept programs is to use the artificial environment of the rearing facilities to increase the overall productivity of the population by increasing survival at life-history stages where competitive or environmental bottlenecks occur. Concurrently, the release strategy for artificial production must not create a new bottleneck in productivity through competition with the naturally produced component of the population. The existing programs and some of the future strategies are supplementation oriented, while other strategies are not intended to integrate artificial production with natural production. These other strategies still require release strategies that will minimize competition with the naturally produced juveniles, as well as consideration for other potential conflicts such as harvest management.

The supplementation based concept for Wenatchee River sockeye salmon is based on the premise that current stock productivity has a major limiting factor because of low spring zooplankton production in Lake Wenatchee. Mullan (1986) hypothesized that low zooplankton densities limited growth and survival of sockeye fry in Lake Wenatchee from fry emergence through early summer, particularly in years with high snow accumulations and resultant nutrient flushing from the lake. The existing production and proposed additional production is designed to circumvent this bottleneck by providing rearing in net pens until fall or mid summer, when zooplankton densities are much higher. This strategy is based on the concept that release of juveniles in mid- summer to fall will not reduce survival of naturally produced sockeye rearing in the lake because food is abundant in late summer and winter survival is probably not density dependent. Alternative options discussed below include extended rearing to yearling release in the spring, which would pose less risk to competitive interaction but increased risk to differential selection and straying of returning adults.

Production concepts proposed for Okanogan River sockeye salmon include both supplementation concept proposals and options for production outside the Okanogan River watershed. The natural production bottlenecks in the Okanogan River appear to be primarily seeding level (underseeding) due to low spawner migration success through the Okanogan River and Lake Osoyoos and poor egg to fry survival because of dewatering of redds and/or scouring of redds during changes in regulated flow regimes in the spawning area. Improvement of prespawn survival and spawning habitat should be the primary focus of compensation efforts, and net pen early rearing for release into the north basin of Lake Osoyoos to benefit from ample rearing capacity in the lake should come next. However, these options are presently precluded due to lack of support from the Canadian government. In lieu of these preferred programs, other options are proposed below that restrict production to releases and adult return into waters within the United States. The primary risk to the natural population is from broodstock collections that reduce the number of adults available to seed Lake Osoyoos. This risk is somewhat mitigated by the fact that 50% of adults die before spawning. If broodstock collection at Wells Dam were programmed to target the portion of the run most prone to low survival (presumed because of high water temperatures in the Okanogan River), then the effect on the natural population could be reduced. Competition and disease transfer in the mainstem Columbia River migration corridor and potential mixed stock harvest considerations are other risks to natural production.

5.5: Risk Assessment

In a similar perspective as that taken for summer and fall chinook salmon, the HWG felt that a rapid increase in hatchery production of sockeye salmon to meet the Phase A Mid-Columbia production objectives may place an unwarranted risk on natural populations. However, the two populations of sockeye salmon in the Mid-Columbia Region are vulnerable to habitat degradation and loss, which causes the HWG concern. They believe the most appropriate means to ensure the viability of these populations is through protection and restoration of critical habitats (this will be addressed in the Mid-Columbia Habitat Program) and increased downstream passage survival (to be addressed in the Mid-Columbia Mainstem Program), yet a cautious approach to increase their abundance through artificial propagation is warranted.

The sockeye salmon BRT (1996) identified that, among other factors, the spatial distribution of spawners is an important factor in assessing the risk of a population to extinction. Important spatial components for the viability of sockeye salmon in the Mid-Columbia Region are spawning grounds, rearing lakes, and adult migration and holding corridors. The degree of threat to these habitats in turn affects the degree of risk of extinction to the native populations. Bugert et al. (1997a) maintain that the spawning habitats for both the Wenatchee and Okanogan populations are highly susceptible to degradation or loss. This may greatly affect the viability of naturally produced sockeye salmon. In the Wenatchee Watershed, most sockeye salmon spawn in the lower 15 km of the White River, which is vulnerable to housing development. Bugert et al. (1997a) identified this as the single most important habitat to protect in the Wenatchee Watershed. In the Okanogan Watershed, the sole spawning habitat is an 11 km reach downstream of McIntyre Dam. This reach is highly susceptible to alternative scouring and dewatering actions by the dam (Chapman et al. 1995b). The HWG felt there is a high likelihood that a catastrophic event may eliminate production of an entire year class; if these events were to occur in sequential years, the population would be jeopardized. If these habitats are not protected, the viability of both sockeye salmon populations may be reduced significantly. The use of artificial propagation to serve as both a supplementation program and a reserve program for the Okanogan population, and as a supplementation program for the Wenatchee population, would buffer these populations from single catastrophic events that may eliminate a year class.

The least risk approach for using artificial propagation to increase abundance of sockeye salmon in the Mid-Columbia Region contains the following components: (1) increase hatchery production incrementally over several salmon generations, while closely monitoring the distribution, demographics, and abundance of natural fish in the region, (2) use the criteria established in sections 1.8 and 5.8 as the basis to determine the levels of hatchery production that are consistent with the objective of maintaining sustainable natural productivity, (3) defer increases in hatchery production if the natural escapement is not increasing in proportion to the total run, (4) clearly identify the factors limiting production for each population, and design artificial propagation strategies that circumvent these limitations, (5) use release strategies that minimize impacts to juvenile natural fish, and (6) provide a reserve program for the Okanogan population that will reduce ecologic impacts to the natural production.

If the Mid-Columbia Hatchery Coordinating Committee believes that the increases in production of sockeye salmon present an unwarranted risk to the natural populations, they may elect to: (1) defer or alter the incremental increases in hatchery production, or (2) develop additional rearing and release strategies that spatially separate the hatchery fish from natural fish. The basis for these decisions will be from the ongoing evaluation programs.

5.6: Wenatchee River

The current production goal of sockeye salmon in the Wenatchee River is 200,000 marked yearling smolts (10,000 lbs. at 20 fpp), released from six floating net pens on the west end of Lake Wenatchee (Table 23). This program is part of the Rock Island Hatchery Complex. Wenatchee River broodstock are collected from the run at large at Tumwater Dam. To increase production of sockeye salmon in the Wenatchee River, the net pens at Lake Wenatchee could be enlarged by 225% to acclimate and release an additional 450,000 sockeye salmon (22,500 lbs. at 20 fpp). Seventeen net pens would be required to meet the total production goal (650,000 yearling pre-smolts at 20 fpp: 32,500 lbs.). Subyearling sockeye salmon would be transferred from Eastbank FH to the net pens in April. Pre-smolts would be acclimated for release in autumn. Full implementation of this strategy is contingent upon the acquisition of required permits for construction and operation of an enlarged net pen operation on Lake Wenatchee.

If permits for full production cannot be secured, or if the HWG determines the preferred strategy is to use alternative rearing strategies to minimize risk to the natural Wenatchee sockeye salmon population, one or both of the following strategies could be used in lieu of some of the net pen production:

1) A small acclimation unit could be built on White River (near the Sears Creek confluence), to be used for sockeye salmon. Semi-natural acclimation could be considered. The pond would acclimate and release 75,000 subyearling sockeye salmon in fall (2,500 lbs. at 30 fpp). This may be used in conjunction with a yearling spring chinook program. Transfer of spring chinook salmon from Chiwawa Ponds would be in March (or earlier if snow conditions allow) for release in May. Sockeye salmon would be transferred from Eastbank FH in June for an October release. If schedules permit, the sockeye could be reared in the empty raceways at Chiwawa Ponds before being split. Pond size and flow requirements would be 3,300 ft^3 and 0.9 cfs, respectively.
2) Eastbank FH could incubate and early rear, and Turtle Rock will overwinter 150,000 sockeye salmon to a yearling stage for a March release into upper Lake Wenatchee. These salmon would be marked differently from the net pen releases for an evaluation of relative performance. This strategy would preclude production of this equivalent biomass of another species (such as summer chinook salmon) at Eastbank FH, because of constraints in late summer water supply.

Broodstock for these programs would be unmarked adults trapped at Tumwater Dam. Gene flow between the fish released from these release sites would be acceptable, at all levels. An approved broodstock collection protocol would be required for each year's collections (Appendix J.4).

5.7: Okanogan River

Cassimer Bar FH is an experimental facility that began operation in 1992 to compensate for passage mortalities of sockeye salmon at Wells Dam. Broodstock for Cassimer Bar production are collected at Wells Dam east ladder and held in vinyl raceways at Cassimer Bar. The facility uses well water to supply two 22 ft circulars, two 8 x 70 ft raceways, and incubation facilities. Production currently is 200,000 subyearlings (8,000 lbs. at 25 fpp).

Most of the freshwater rearing, and all the spawning habitat lies within Canada, yet this population is in the United States (and subject to the actions of the MCMCP) only during its migration through the lower Okanogan and Columbia rivers. At this time, the provincial and federal governments of Canada do not support expanded sockeye salmon production in the Okanogan Region, because of the risk of affecting important resident fish populations. While many measures are proposed to benefit this population in the migration corridor (through passage improvements and habitat restoration), it is likely that these measures will not be sufficient to sustain a harvestable surplus. Pratt et al. (1991) concluded that the nursery lake could support a higher seeding level, and suggested that streamside and lake incubators could be feasible options to increase overall seeding and productivity of Lake Osoyoos.

The sockeye salmon *ad hoc* group of the Wells Coordinating Committee identified the preferred production alternative as subyearling net pen releases in the north basin of Lake Osoyoos. Additional measures for sockeye salmon production could be used when the transboundary issue is resolved. However, until the issue is resolved, the only viable option is production of fish that return to waters solely within the United States. Some limited hatchery supplementation solely within the United States is feasible, yet the only available approach to propagate substantial numbers of Okanogan sockeye salmon may be away from their nursery lake (Allen and Meekin 1980). Production of many of these groups will not be at the yearling stage during this phase, because of logistical constraints in fish culture.

In Phase A of the Mid-Columbia Hatchery Program, Cassimer Bar FH would be modified to spawn, incubate, and rear Okanogan sockeye for acclimation and release from net pens placed in the forebay of Chief Joseph Dam (Lake Rufus Woods). Initially, production would be 200,000 yearlings (20,000 lbs. at 10 fpp) to test the feasibility of this program (currently planned under the Wells Settlement Agreement). If successful, and if transboundary issues remain unresolved, hatchery facilities will be built or modified to increase production to 300,000 yearlings (30,000 lbs. at 10 fpp). Broodstock would be collected from Wells Dam east ladder. Transfer would be made in June for a May release. The pens could be pulled to the front of the ice/trash sluiceway for release and passage through the dam. This program would be politically feasible because all aspects of production, including adult returns, lie within the United States.

In Phase B, after the transboundary issue is resolved, four production programs options may be initiated to increase natural production of Lake Osoyoos. Not all of these options (Table 23) may be used:

1) Net pens would produce 375,000 (15,000 lbs. at 25 fpp) sockeye salmon in the north basin of Lake Osoyoos. As this program exceeds Cassimer Bar FH capacities, additional incubation and early rearing facilities would have to be sited.
2) Streamside and lake incubators will be installed at Lake Osoyoos to increase the lake seeding level. A limited pilot project could be pursued, using ten incubators to introduce 200,000 emergent fry into the lake. Some maintenance (probably by Cassimer FH staff) would be required. Broodstock would be collected at Wells Dam east ladder.
3) Wells FH would be modified to spawn, incubate, and rear 100,000 (10,000 lbs. at 10 fpp) marked yearling sockeye salmon for release into the lower basin of Lake Osoyoos. Broodstock would be unmarked sockeye salmon intercepted at Wells Dam.
4) If transboundary issues still preclude release of hatchery sockeye salmon into Canadian waters, an acclimation pond would be built on the east bank of the Okanogan River, immediately downstream of Zosel Dam, for overwinter rearing and release of sockeye salmon. This program would produce 300,000 yearlings (25,000 lbs. at 12 fpp). Okanogan sockeye salmon would be trapped at the Wells Dam east ladder. Holding, spawning, incubation, and interim rearing would be at one of three locations, depending on late summer water availability: Wells FH, Cassimer Bar FH, or Colville FH.

Gene flow among all production programs in the Okanogan Watershed would be acceptable. An approved broodstock collection protocol would be required for each year's collections. To reduce the potential for adverse effects on natural production, a detailed broodstock collection protocol (Appendix J.4) will be used.

Passage barriers severely confine the distribution and abundance of Okanogan salmonids. The notable barriers (McIntyre Dam on the Okanogan and Enloe Dam on the Similkameen) both prevent complete sockeye salmon penetration into British Columbia. At this time, no efforts to provide passage are being considered. However, barriers on Salmon Creek may be made passable through the Mid-Columbia Habitat Program (and through other means). If these problems are rectified, Okanogan sockeye salmon could be introduced to the lower Conconully Reservoir (and potentially the upper reservoir), through a cooperative venture with the Okanogan Irrigation District. Besides the passage improvements in Salmon Creek, some modification of the head gates at Lower Conconully Reservoir would be required. A potential introduction would be 200,000 subyearlings (8,000 lbs. at 25 fpp) reared in a net pen in the lower reservoir. Broodstock would be collected at Wells Dam, and supplemented by Salmon Creek collections.

Table 23. Current production objective of sockeye salmon in the Mid-Columbia Region, and future production under the Mid-Columbia Mainstem Conservation Plan.

		Current production objective		Future production objective[b]	
Population	Facility	Number	pounds	Number	pounds
Wenatchee	Net pen	200,000	10,000	500,000	25,000
	White River	0	0	75,000	2,500
	Eastbank/ Turtle Rock	0	0	150,000	15,000
Subtotals		*200,000*	*10,000*	*725,000*	*42,500*
Okanogan	North Basin net pen	200,000	8,000	375,000	15,000
	Wells	0	0	100,000	10,000
	Zosel	0	0	300,000	12,000
	Incubators	0	0	200,000	- -
	Rufus Woods[a]	0	0	300,000	30,000
	Conconully	0	0	200,000	8,000
Subtotals		*200,000*	*8,000*	*1,475,000*	*75,000*
Totals		400,000	18,000	2,200,000	115,500

[a] *The Rufus Woods program is the sole Phase A production program for Okanogan sockeye salmon under the Mid-Columbia Hatchery Program.*

[b] *Some or all of the listed programs would be initiated in Phase B to meet the interim NNI production objective--not all of these programs may be used to meet the equivalent of 1,443,000 yearling sockeye salmon smolts.*

5.8: Monitoring and Evaluation

Most of the sockeye salmon evaluations for the Mid-Columbia Hatchery Program will address the most effective means to increase natural production of the two rearing lakes. Specific questions to be addressed are: (1)What is the survival rate from release to emigration of juvenile sockeye salmon in Lake Wenatchee and, if the transboundary issue is resolved, in Lake Osoyoos? (2) What is the population size of hatchery and wild sockeye salmon that emigrate from Lake Wenatchee and, if the transboundary issue is resolved, Lake Osoyoos? (3) What is the smolt to adult survival rate for hatchery and wild sockeye salmon? and (4) In Lake Wenatchee, what release strategy for sockeye salmon reduces predation by bull trout? Additional evaluations will determine if the Mid-Columbia Hatchery Program is capable of meeting the Phase A sockeye salmon production objectives.

For the Lake Wenatchee production, these questions will be addressed through the following objectives: (1) evaluate the release strategy for net pen reared sockeye salmon, (2) determine the extent of predation/mortality during the release period, (3) determine the post-release fingerling-to-smolt survival rate of hatchery-reared juvenile sockeye salmon, (4) determine the post-release growth of hatchery-reared juvenile sockeye, (5) estimate populations of hatchery and wild juvenile sockeye emigrating from Lake Wenatchee, (6) describe physical characteristics of Lake Wenatchee and the Wenatchee River that initiate emigration, and (7) determine the smolt-to-adult survival rate of Lake Wenatchee sockeye through extensive spawning surveys. To accomplish these objectives, the following tasks will be undertaken:

- Physical characteristics of the lake and river shall be monitored and the relationship between the number of fish emigrating and temperature, discharge and photoperiod shall be determined through regression analysis.
- Fish growth and health of hatchery sockeye smolts shall be compared to pre-release samples and wild sockeye smolts emigrating from the lake. Organosomatic indices will be determined for hatchery-reared sockeye before the release and during the emigration period.
- Spawning surveys will be conducted weekly on each river. Spent fish and carcasses will be recovered and determined to be hatchery or wild origin. In addition, scales, otoliths, and lengths (post orbital to hypural plate) will be collected to determine the age structure of the population.
- Fingerling-to-smolt survival rates of hatchery-reared sockeye will be calculated by dividing the estimated total number of hatchery sockeye emigrating from the lake by the total number released into the lake the previous fall. The fingerling-to-smolt mortality rate of hatchery sockeye salmon could be used to adjust smolt-to-adult survival estimates.
- Define annual and long-term changes in the spawning distribution of the donor population. Determine from mark recoveries if enough hatchery adults spawn within the established spawning area of the donor population to replace adults taken for broodstock. Determine if hatchery-reared adults reproduce effectively in terms of distribution with the naturally produced spawners, timing, and habitat use.
- Weekly spawning ground surveys will be done to determine if there is a difference in the spawn timing of wild and hatchery fish. Determine egg retention of marked and unmarked fish in the donor population by opening carcasses of females.
- Relate redd count to escapement in donor stream to develop adult multiplier for redds (e.g. adults per redd). Estimate proportion of carcasses of hatchery origin. Estimate numbers of marked adults that spawn in each donor stream (Hatchery Spawning Escapement = Redds X Proportion Hatchery X Redd Multiplier).
- Smolt-to-adult survival will be estimated by dividing the total number of hatchery sockeye salmon adults returning to the Columbia River by the estimated number of smolts that emigrate from Lake Wenatchee, during the respective brood year. Escapement to the Wenatchee River will be measured by counts at Tumwater Dam.

To assess the capability of the hatcheries in meeting survival guidelines (Table 11) and the overall production objectives of the Mid-Columbia Hatchery Program the following evaluation objectives will be done: (1) determine the survival rates of various life stages of sockeye salmon at the hatchery and net pens, (2) determine if Cassimer Bar can accelerate growth and development of sockeye salmon as a means to produce a subyearling smolt, and (3) monitor fish health and develop cultural methods to alleviate fish health problems.

- Monitor pre-spawning mortality of broodstock
- Determine egg to fry and fry to smolt survival rates for sockeye salmon prior to release.
- Monitor growth and feed conversion rates of sockeye salmon juveniles reared at both hatchery and net pens.
- Document hatchery techniques applied during each life stage. Records should include, but not be limited to, broodstock collection dates, time of spawning, thermal units during incubation, hatching dates, early rearing temperatures, density at splits, ponding dates and densities, feeding schedules, net pen loading rates and lake temperatures.
- Conduct routine (monthly) fish health monitoring by qualified fish health specialists to assess the presence of specific pathogens that are known to occur in sockeye salmon.

- Develop means to segregate egg/progeny based on levels of Rs antigen, which allows for protection of negative progeny form potential horizontal transmission of disease from positive progeny. Progeny of any required segregation will also be tested by ELISA at the first opportunity and prior to transfer to the net pens.

SECTION 6: COHO SALMON

6.1: Background

The reintroduction of coho salmon to the Mid-Columbia Region is an issue to be resolved outside the scope of the Mid-Columbia Hatchery Program. However, coho salmon will be included as a Plan Species in the MCMCP. As coho salmon reintroduction efforts proceed, the same mitigative measures afforded to other Plan Species shall be provided to coho salmon that are produced from the Mid-Columbia Region. Off-site compensation activities for coho salmon to achieve NNI shall be based on losses to naturally produced coho salmon, losses to second-generation hatchery-reared coho salmon from adults returning to the Mid-Columbia Region, and losses to adults to the Mid-Columbia Region from both reintroduction efforts and coho salmon produced in the Mid-Columbia Region.

6.2: Management Assessment

In 1997, the Yakama Indian Nation initiated a reintroduction program for selected tributaries of the Mid-Columbia Region with early stock coho salmon from lower Columbia River hatcheries in order to restore natural production identified in the Yakama Nation's "Coho Salmon Species Plan" for the Mid-Columbia Basin (CSSP). The goal of this program is to initiate restoration of coho salmon populations in mid-Columbia tributaries to levels of abundance and productivity sufficient to support sustainable annual harvest by tribal and other fishers.

In 1996, YIN staff identified selected habitats and acclimation pond sites in the Methow and Wenatchee watersheds for the potential reprogramming of adult and/or juvenile coho salmon from appropriate lower river hatcheries. It is expected that when adults are transferred, they will spawn naturally in areas close to where they are released with the resulting production rearing in suitable production areas identified in the CSSP. Similarly, juvenile releases would rear up to one year in suitable production areas, then return after ocean migration to these same areas to spawn. Pre-smolts would be acclimated for one month in low-cost ponds prior to their release. A full description of this program is in CSSP.

In 1996, YIN implemented a small feasibility study by releasing 350,000 early run coho salmon juveniles into the Methow Watershed. Of these, 100,000 smolts were acclimated two weeks in the Fulton Irrigation canal and volitionally released into Chewuch River. The remaining 250,000 smolts were acclimated one month at Winthrop NFH and released directly into Methow River.

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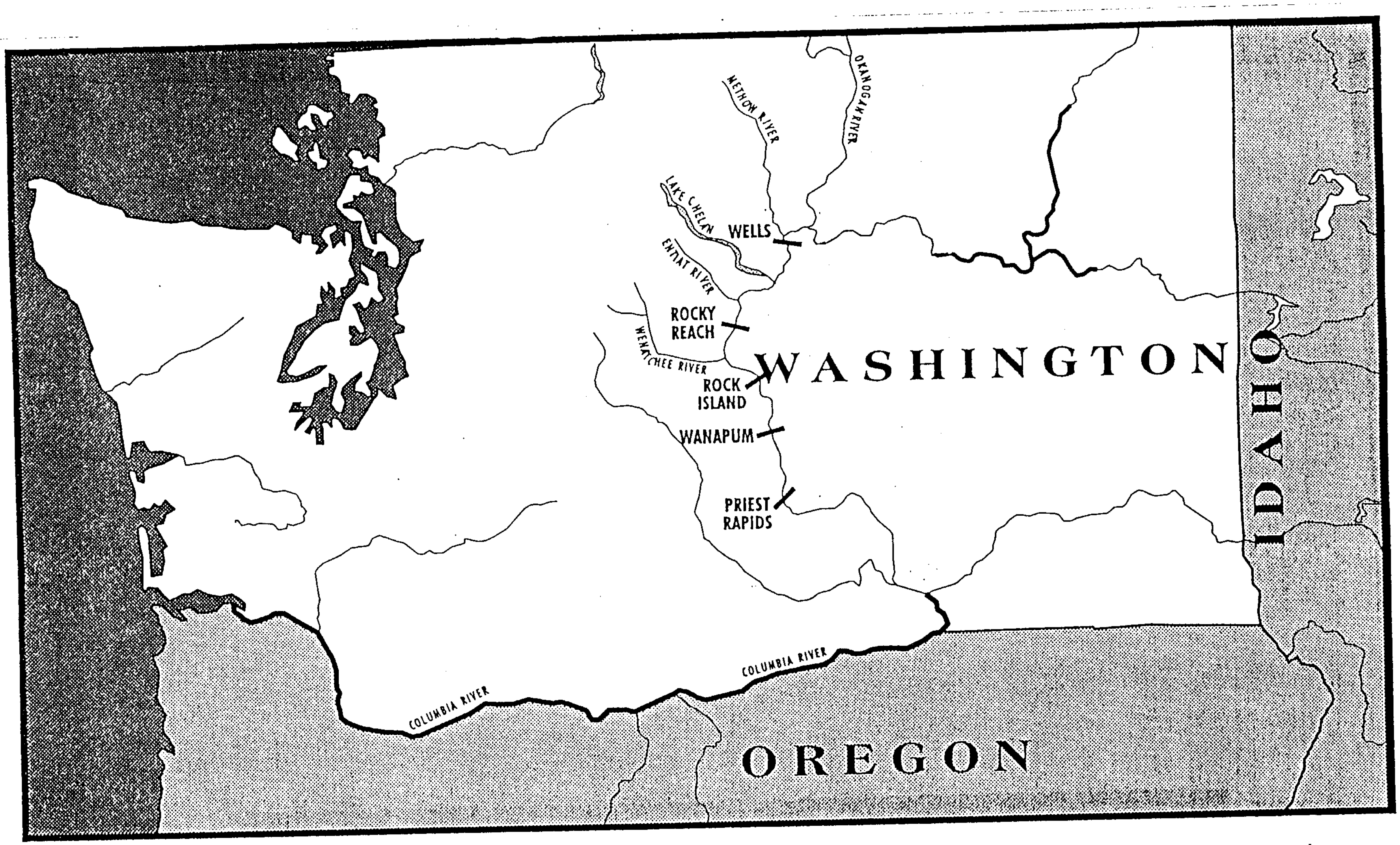


Figure 1. Map of Washington State, showing location of five mid-Columbia hydroelectric projects and reach encompassed by the Habitat Conservation Plan.

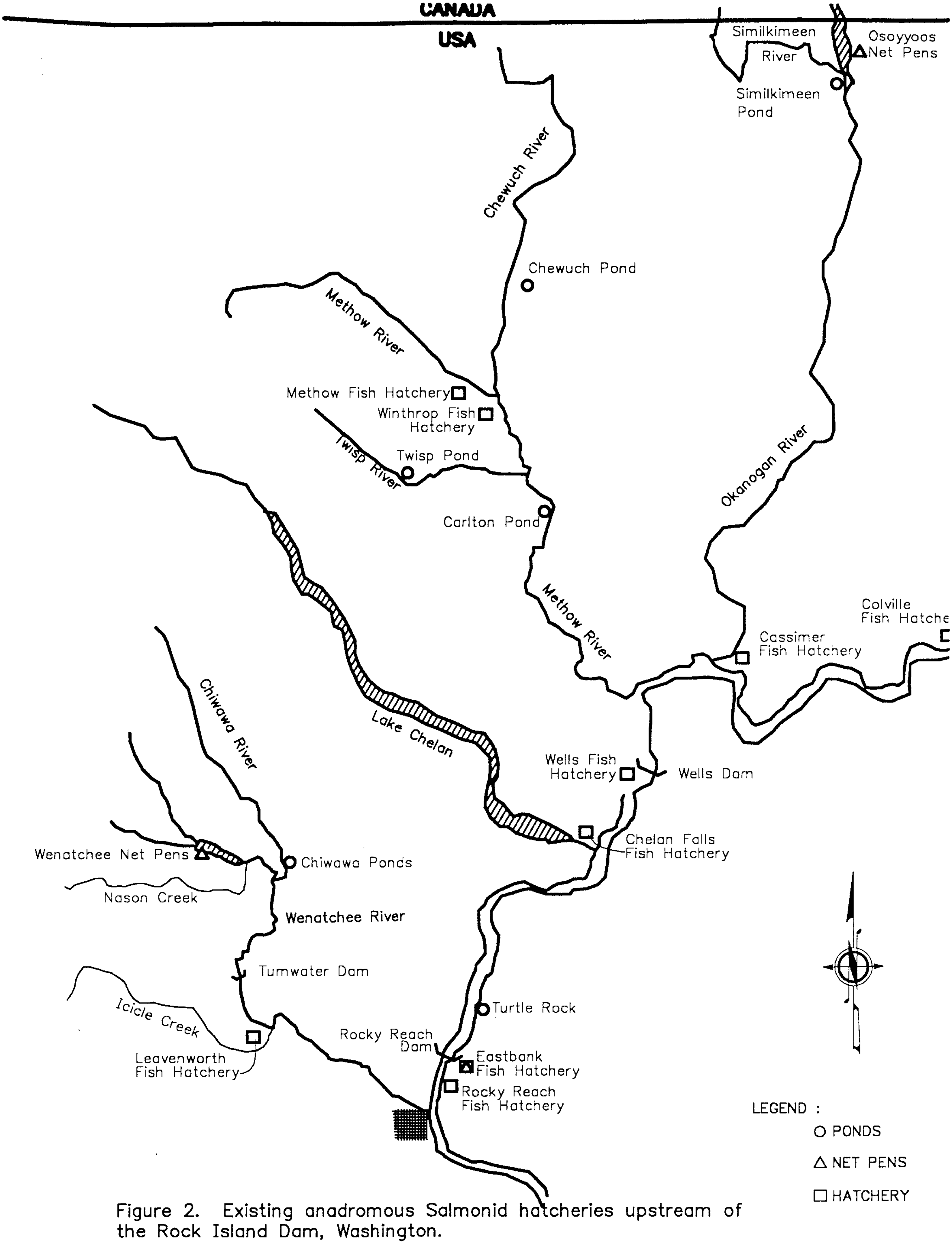


Figure 2. Existing anadromous Salmonid hatcheries upstream of the Rock Island Dam, Washington.

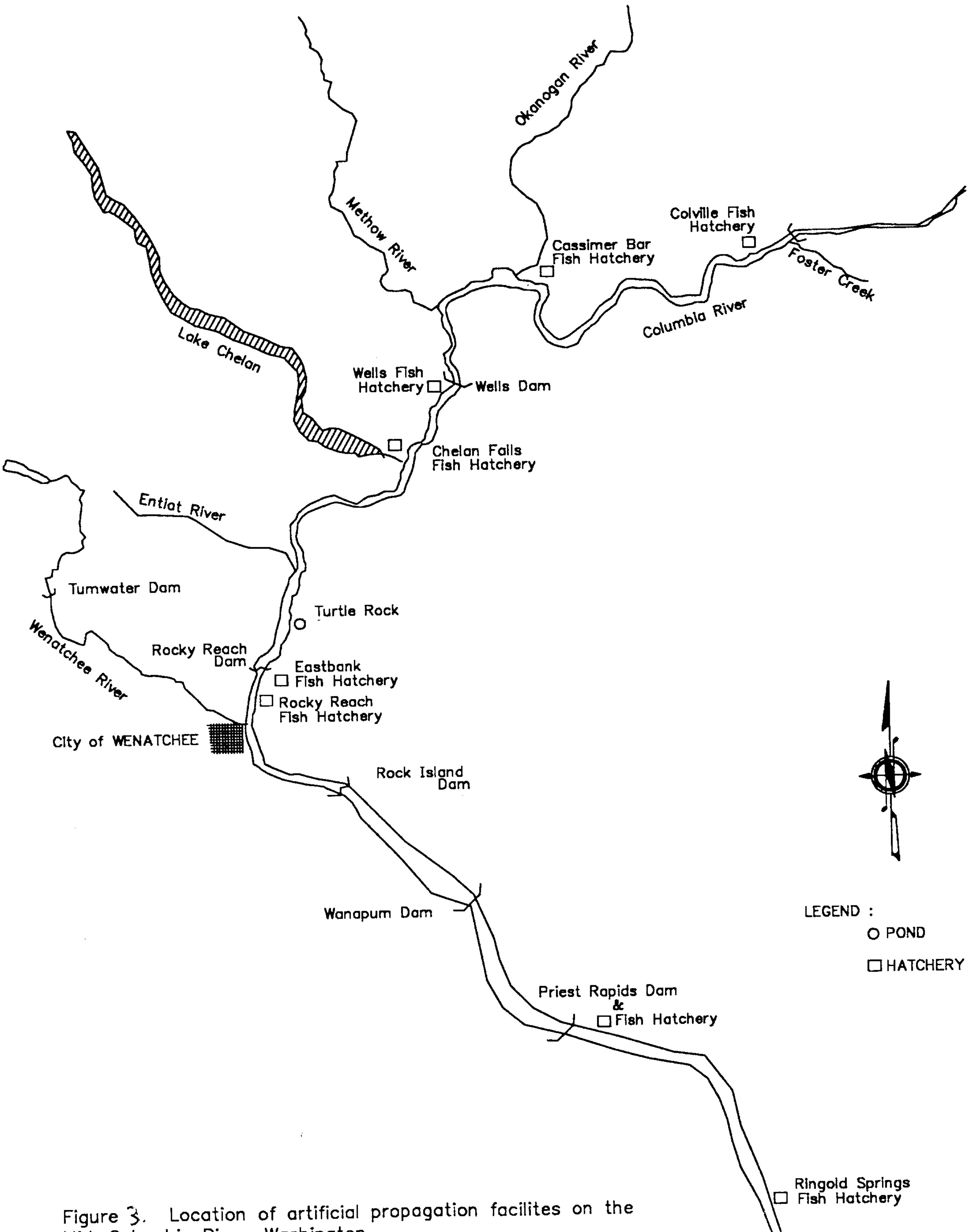


Figure 3. Location of artificial propagation facilites on the Mid–Columbia River, Washington.

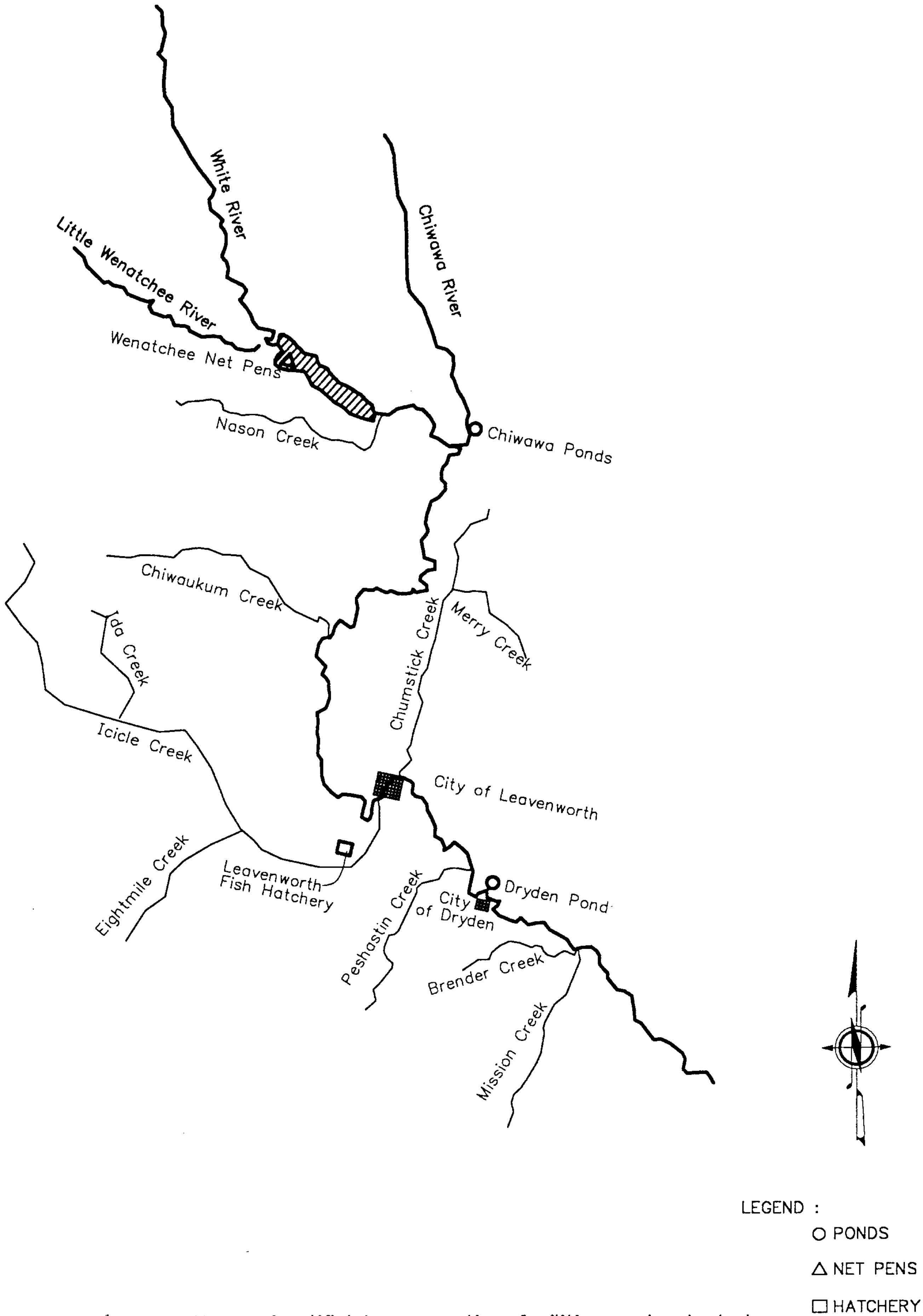


Figure 4. Locations of artificial propagation facilities and selected streams in the Wenatchee River, Washington

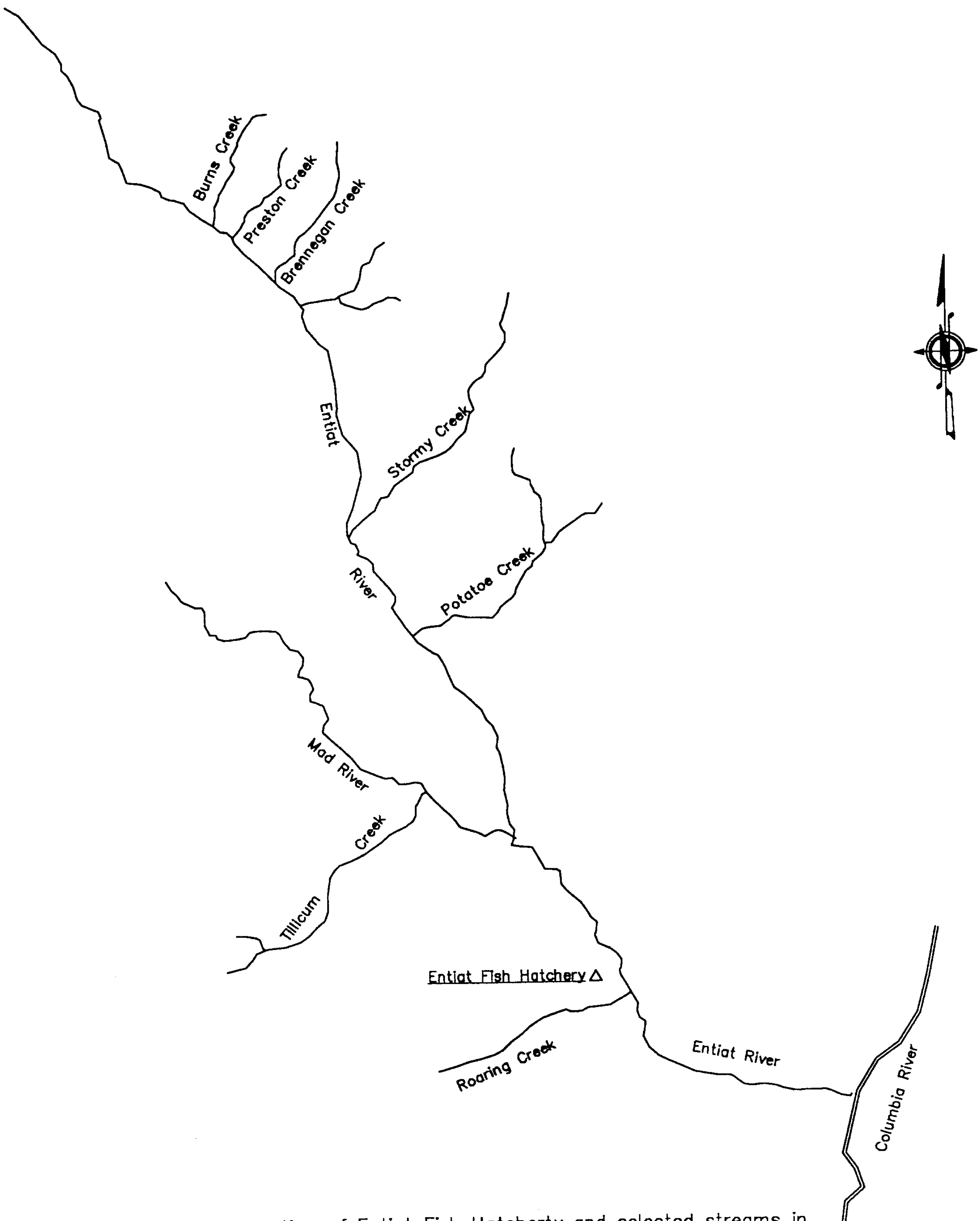


Figure 5. Location of Entiat Fish Hatcherty and selected streams in the Entiat Basin, Washington.

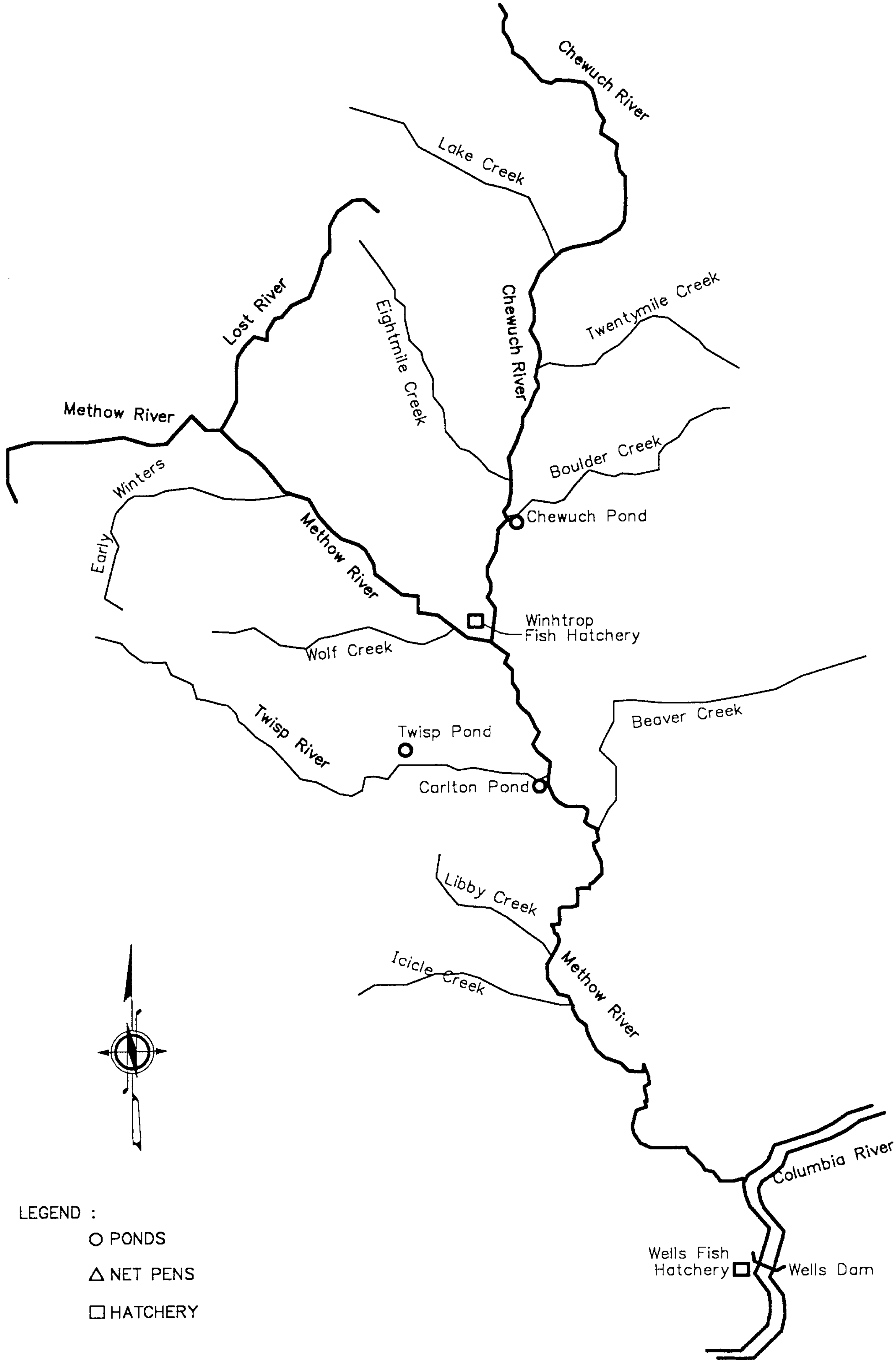


Figure 6. Location of hatcheries, acclimation ponds and selected streams in the Methow Basin, Washington.

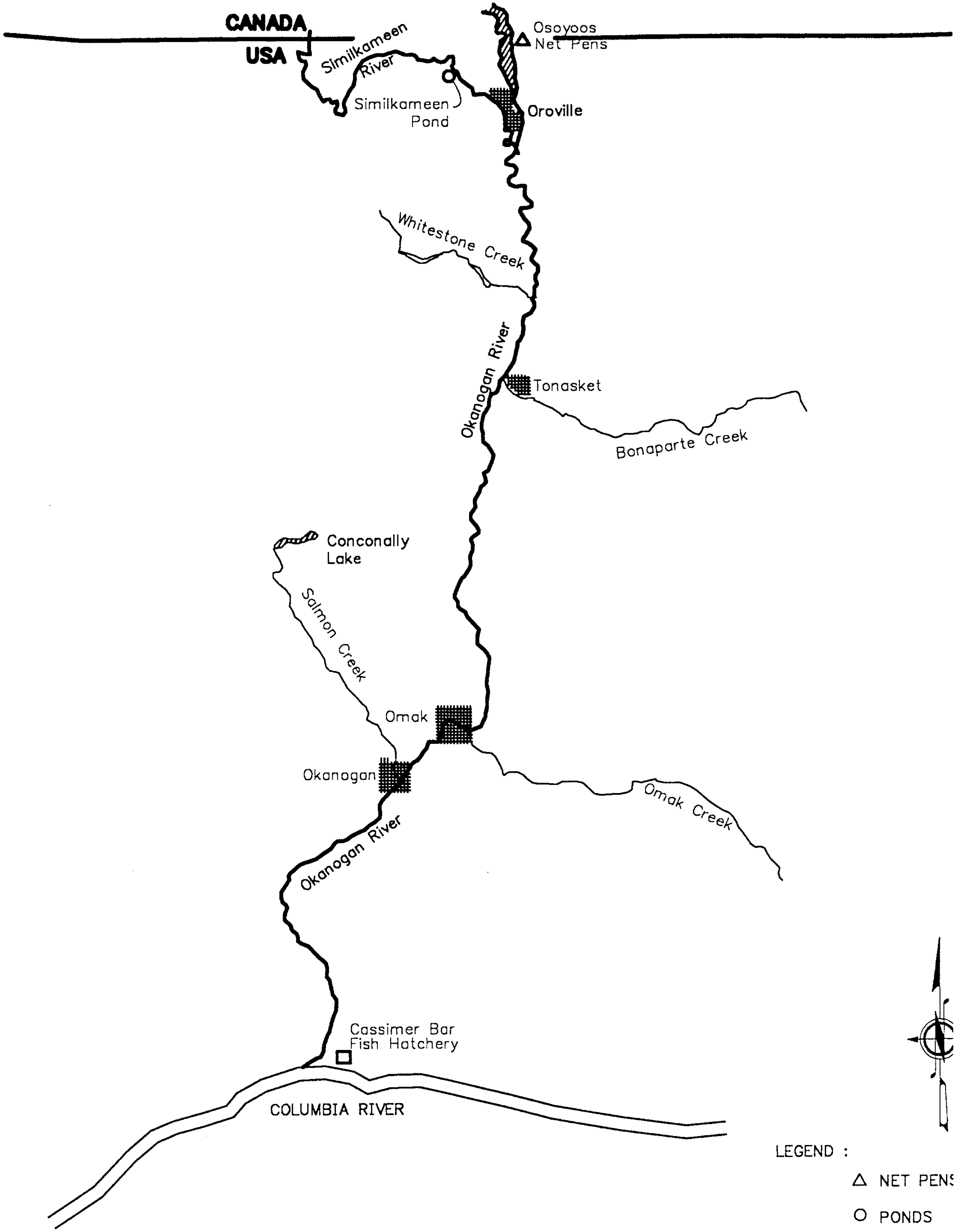


Figure 7. Location ofartificial propagation facilities and selected streams in the Okanogan Basin, Washington.

Appendix A. Definition of terms.

Artificial propagation:	Any assistance provided by humans in fish reproduction. This assistance includes, but is not limited to, spawning and rearing in a hatchery, stock transfers, and out planting of fish at any life stage into the natural environment.
Artificial reserve:	A program that brings all or part of a population into captivity for all or a portion of the life cycle in order to reduce the population's probability of extinction.
Broodstock:	A group of adult or maturing fish, usually representing a certain population, that are used to generate a subsequent population.
Captive brood program:	Artificial rearing through maturation for at least one generation with the intent of variable age releases into the natal stream at an undetermined time.
Conservation hatchery:	An artificial propagation facility with a primary objective to maintain, to the maximum practicable extent, the genotypic and phenotypic characteristics of the targeted population.
Escapement:	The number of salmon or steelhead that return to a specified measuring location after all natural mortality and harvest have occurred. Spawning escapement consists of those fish that survive to spawn.
Hatchery fish:	Fish that has been spawned, incubated, and has emerged in a hatchery.
Metapopulation:	A set of local breeding populations connected by exchange of individuals (NRC 1996).
Native stock:	An interbreeding group of fish that historically reproduced naturally in a given watershed. Fish in this population may be of hatchery or natural parentage.
Natural fish:	Fish that are progeny of naturally spawning parents. Natural fish thus spend their entire life cycle (except perhaps for brief periods in conservation facilities such as fish ladders or transportation barges) in natural habitat (From Hard et al. 1992).
Natural cohort replacement rate:	The number of naturally spawning adults that were naturally produced divided by the number of naturally spawning parents (regardless of parentage) in the previous generation.
Natural reserve:	A geographic area which contains populations, groups of populations, or entire ecosystems that are protected from one or more anthropogenic effects.

Non-native stock:	A group of fish that are historically from a location outside that of the population of interest. Typically, but not always, these fish may be identified as non-native by genotypic, demographic, or artificial means (such as a mark).
Population:	A group of historically interbreeding salmon of hatchery, natural, or unknown parentage that have developed a unique gene pool. They often, but not always, can be separated from another population by genotypic or demographic characteristics. This term is synonymous with stock.
Productivity:	The capability for naturally reproducing populations to perpetuate from one generation to the next, measured in this assessment as the natural cohort replacement rate.
Production capacity:	The maximum number of fish a given watershed can produce, measured in this assessment as smolts.
Production hatchery:	An artificial propagation facility with an objective to augment harvest by the development of fish populations that rely heavily on artificial spawning and rearing in a hatchery. These hatchery programs are not necessarily designed to contribute to the abundance of naturally-spawning fish populations.
Propagation survival:	The percent of progeny from a given fish, or group of fish, that survive from time of parental broodstock collection to time of release for downstream migration. Parents that die in the traps, or are killed by the trap facilities during upstream migration, are to be included in this calculation. Moribund salmon that drift downstream and die on the trap facility are not to be included.
Overall survival:	The percent of progeny that survive from time of parental broodstock collection to spawning, or interception in a fishery or during migration.
Seeding level:	The degree to which a unit of habitat has approached its production capacity, generally expressed as a percentage.
Smolts:	The life stage of salmon or steelhead in which physiological and behavioral changes prepare the fish for transition from freshwater to saltwater. Generally this occurs at the onset of active downstream migration.
Smolt yield:	The number of smolts that leave a watershed and enter the mainstem Columbia River in a given year.
Stray:	A fish of any origin that returns to spawn in a population other than that of its parents.

Supplementation:	Use of artificial propagation to establish or increase the abundance of naturally reproducing populations, while maintaining their long-term fitness, and keeping the ecological impacts on non-target species, both within and outside the basin, within specified limits (adapted from RASP 1992).
Tiered collection:	Priority and ancillary collection strategies are established (each has different hazards and benefits). In-season collection decisions are made on the relative use of each strategy, depending upon current conditions (run size, snow pack, etc.) thereby minimizing overall risk.

Appendix B. Members of the Mid-Columbia Mainstem Conservation Plan Hatchery Work Group.

Name	Affiliation
Dale Bambrick	Yakama Indian Nation
Tim Bodurtha	U. S. Fish and Wildlife Service
Larry Brown	Washington Department of Fish and Wildlife
Bob Bugert	Mid-Columbia Public Utility Districts; group facilitator
Craig Busack	Washington Department of Fish and Wildlife
Don Campton	U. S. Fish and Wildlife Service
Brian Cates	U. S. Fish and Wildlife Service
Tom Cooney	Washington Department of Fish and Wildlife
Mike Cuenco	Columbia River Inter Tribal Fish Commission
Joe Foster	Washington Department of Fish and Wildlife
Mike Ford	National Marine Fisheries Service
Steve Hays	Chelan County Public Utility District
Stuart Hammond	Grant County Public Utility District
Gary James	Confederated Tribes of the Umatilla Indian Reservation
John Kerwin	Washington Department of Fish and Wildlife
Rick Klinge	Douglas County Public Utility District
Steve Landino	National Marine Fisheries Service
Joe Lukas	Grant County Public Utility District
Jerry Marco	Colville Confederated Tribes
Steve Parker	Yakama Indian Nation
Tom Scribner	Yakama Indian Nation
Steve Smith	National Marine Fisheries Service
Andre Talbot	Columbia River Inter Tribal Fish Commission
Robin Waples	National Marine Fisheries Service
Rick Westerhoff	National Marine Fisheries Service
Rod Woodin	Washington Department of Fish and Wildlife

Appendix C. Production objectives, and recent 3 to 7 year average production of hatchery salmonids in the Mid-Columbia Region.

Species Stream	Hatchery	Production objectives	Average production
Spring chinook salmon			
Methow River	Winthrop FH	800,000	479,952
	Methow FH	738,000	184,798
Entiat River	Entiat FH	800,000	621,032
Wenatchee River	Leavenworth FH	1,625,000	1,903,403
	Chiwawa Ponds	672,000	70,608
Total		4,635,000	
Summer chinook salmon			
Okanogan River	Similkameen Pond	576,000	529,571
Methow River	Carlton Pond	400,000	438,798
Wenatchee River	Dryden Pond	864,000	415,738
Columbia River	Wells FH	804,000	657,250
Columbia River	Turtle Rock	1,820,000	1,398,950
Total		4,464,000	
Fall chinook salmon			
	Priest Rapids FH	5,000,000	5,000,000
Sockeye salmon			
Okanogan River	Cassimer Bar FH	200,000	
Wenatchee River	Eastbank FH	200,000	224,369
Total		400,000	
Summer steelhead			
Okanogan River	Wells FH	100,000	
Methow River	Wells FH	350,000	
	Winthrop FH	100,000	
Entiat River	Chelan/Turtle Rock	40,000	42,230
Wenatchee River	Eastbank FH	200,000	176,278
	Chelan/Turtle Rock	160,000	150,050
Total		950,000	
Grand total		15,449,000	

Appendix D. Status matrices for steelhead and spring chinook salmon.

Table D1. Matrix for expected status of mid-Columbia River steelhead populations in 10 years without supplementation

	Status					
	All morphs extinct	Anadromy extinct[1]	Nearly extinct[2]	< 100 fish/year	100-500 fish/year	> 500 fish/year
Wenatchee Basin						
Chiwawa River	0.00	0.03	0.13	0.50	0.29	0.04
Nason Creek	0.00	0.03	0.19	0.53	0.24	0.01
Little Wenatchee R.	0.00	0.03	0.23	0.59	0.14	0.01
White River	0.00	0.03	0.23	0.57	0.17	0.01
Lower river	0.00	0.10	0.26	0.47	0.17	0.01
Entiat Basin						
Upper river	0.00	0.07	0.26	0.51	0.14	0.01
Mad River	0.00	0.10	0.31	0.51	0.08	0.01
Lower river	0.03	0.07	0.34	0.44	0.11	0.01
Methow Basin						
Upper river	0.00	0.12	0.25	0.46	0.16	0.01
Chewuch River	0.00	0.12	0.25	0.49	0.14	0.01
Twisp River	0.00	0.12	0.25	0.49	0.14	0.01
Lower river	0.00	0.13	0.25	0.48	0.14	0.01
Columbia tributaries	0.08	0.15	0.41	0.30	0.05	0.01

1 Resident forms of *O. mykiss* persist in headwaters, yet does not crossover into anadromous forms.

2 Resident forms are viable. Anadromous forms contribute to population, but at very low levels. Year classes may be totally absent in anadromous spawners.

Table D2. Matrix for expected status of mid-Columbia River steelhead populations in 50 years without supplementation.						
	Status					
	All morphs extinct	Anadromy extinct[3]	Nearly extinct[4]	< 100 fish/year	100-500 fish/year	> 500 fish/year
Wenatchee Basin						
Chiwawa River	0	0.07	0.3	0.46	0.16	0.01
Nason Creek	0	0.11	0.37	0.41	0.1	0.01
Little Wenatchee R.	0	0.14	0.31	0.45	0.09	0.01
White River	0	0.13	0.3	0.45	0.11	0.01
Lower river	0	0.17	0.31	0.41	0.1	0.01
Entiat Basin						
Upper river	0	0.15	0.39	0.39	0.07	0
Mad River	0	0.18	0.4	0.38	0.04	0
Lower river	0.07	0.14	0.39	0.36	0.04	0
Methow Basin						
Upper river	0	0.19	0.4	0.3	0.1	0.01
Chewuch River	0	0.19	0.39	0.33	0.09	0.01
Twisp River	0	0.19	0.36	0.36	0.09	0.01
Lower river	0	0.21	0.34	0.36	0.09	0.01
Columbia tributaries	0.1	0.21	0.47	0.21	0.01	0.01

3 Resident forms of *O. mykiss* persist in headwaters, yet does not crossover into anadromous forms.

4 Resident forms are viable. Anadromous forms contribute to population, but at very low levels. Year classes may be totally absent in anadromous spawners.

Table D3. Matrix for expected status of mid-Columbia River spring chinook populations in 10 years without supplementation					
	Status				
	Extinct	Nearly extinct[5]	< 100 fish/year	100-500 fish/year	> 500 fish/year
Wenatchee Basin					
Chiwawa River	0.02	0.18	0.46	0.30	0.05
Nason Creek	0.03	0.25	0.48	0.23	0.01
Little Wenatchee R.	0.11	0.41	0.43	0.05	0.00
White River	0.09	0.36	0.43	0.11	0.00
Entiat Basin	0.06	0.39	0.41	0.15	0.00
Methow Basin					
Twisp River	0.06	0.26	0.48	0.19	0.01
Chewuch River	0.05	0.22	0.51	0.21	0.01
Methow River	0.04	0.20	0.50	0.25	0.01
Lost River	0.11	0.38	0.48	0.03	0.00

[5] Population present, but at very low levels. Year classes may be totally absent in spawners.

Table D4. Matrix for expected status of mid-Columbia River spring chinook populations in 50 years without supplementation.					
	Status				
	Extinct	Nearly extinct[6]	< 100 fish/year	100-500 fish/year	> 500 fish/year
Wenatchee Basin					
Chiwawa River	0.14	0.35	0.34	0.14	0.03
Nason Creek	0.19	0.37	0.29	0.12	0.01
Little Wenatchee R.	0.31	0.45	0.20	0.04	0.01
White River	0.33	0.35	0.28	0.11	0.01
Entiat Basin	0.31	0.29	0.28	0.11	0.01
Methow Basin					
Twisp River	0.23	0.38	0.26	0.11	0.03
Chewuch River	0.24	0.40	0.24	0.09	0.02
Methow River	0.22	0.41	0.26	0.09	0.02
Lost River	0.46	0.28	0.21	0.06	0.00

[6] Population present, but at very low levels. Year classes may be totally absent in spawners.

Appendix E. Genetic/demographic/ecologic groupings for mid-Columbia River spring chinook salmon and steelhead, based upon analysis by the Mid-Columbia Hatchery Work Group.

Figure E1: Mid-Columbia spring chinook salmon gengtic/ecologic grouping, developed by the Mid-Columbia Hatchery Work Group, 27 February 1997

GROUP

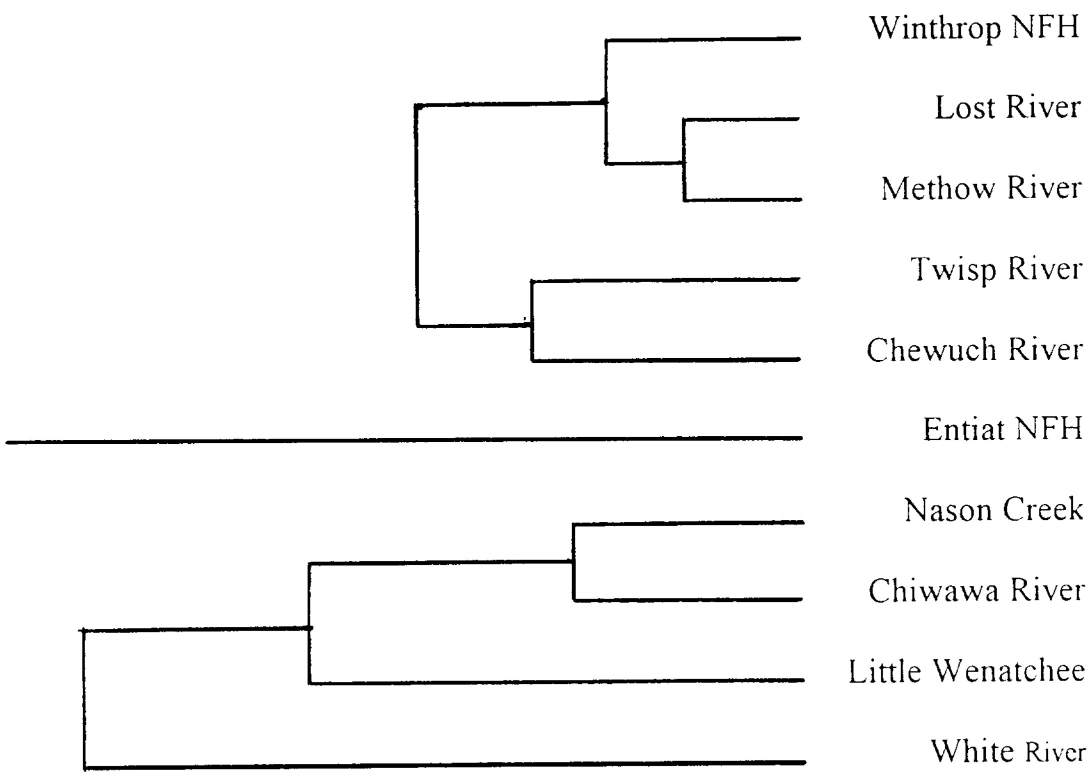
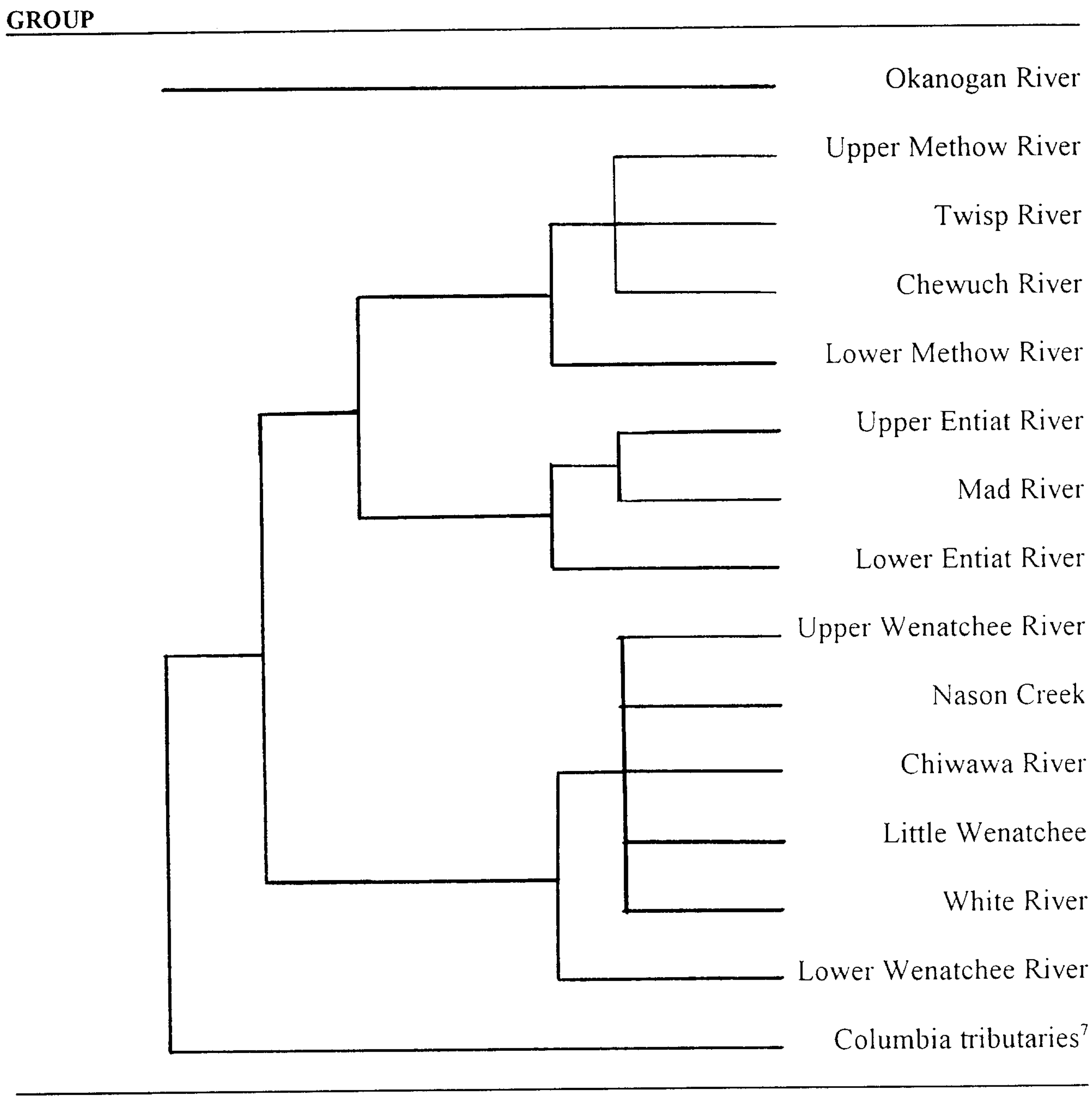


Figure E2. Mid-Columbia steelhead demographic/ecologic grouping, developed by the Mid-Columbia Hatchery Work Group, 7 March 1997



[7] *Sand Creek, Trinidad Creek, Colockum Creek, Tarpiscan Creek, Tekison Creek, Johnson Creek, Brushy Creek, Quilomene Creek, Crab Creek.*

Appendix F. Current production objectives for hatcheries in the Mid-Columbia Region.

Table F1. Current production objectives for hatcheries in the region which release salmonids in the Wenatchee Watershed.

Facility Species	Stock	Number	Broodstock required	Age	Length (mm)	Location	Month
RIHC (Eastbank FH)							
Summer steelhead	Wenatchee	200,000	200	1+	195	scattered	Apr-May
Spring chinook salmon	Chiwawa	672,000	400	1+	160	Chiwawa	Apr-May
Summer chinook salmon	Wenatchee	864,000	476	1+	160	Dryden	Apr-May
Sockeye salmon	Wenatchee	200,000	300	1+	110	Lake Wenatchee	Jul-Oct
Chelan FH/Turtle Rock							
Summer steelhead	Wenatchee	160,000	- -[b]	1+	195	scattered	Apr-May
Leavenworth FH							
Spring chinook salmon	Leavenworth	1,625,000	1,100	1+	170	Icicle	Apr

[a] *The actual number of ocean and stream-type chinook salmon released since the hatchery's inception is less than the production objectives, because of poor natural escapement and/or difficulties in trapping appropriate broodstock. The production goal, and resultant broodstock requirements, at RIHC vary depending upon run strength. The values given in this table are for full production.*

[b] *Steelhead are collected in the Wenatchee River and used as a common broodstock for the Eastbank and Chelan/Turtle Rock programs. The actual broodstock needs for a given facility cannot be determined. The 1996 brood was collected at Priest Rapids and Dryden dams to begin development of a Wenatchee broodstock.*

Table F2. Current production objectives for hatcheries in the region which release salmonids in the Entiat Watershed.

Facility Species	Stock	Number	Broodstock required	Age	Length (mm)	Location	Month
Chelan/Turtle Rock FH							
Summer steelhead	Wells	400,000	- -[a]	1+	195	scattered	Apr-May
Entiat FH							
Spring chinook salmon	Mixed	400,000 400,000	625	1+ 0	170 75	Entiat Entiat	Apr June

[a] *Steelhead are collected at Wells Dam and used as a common broodstock for several programs within the Mid-Columbia Region. The actual broodstock needs for a given facility cannot be determined.*

Appendix F, continued.

Table F3. Current production objectives for hatcheries in the region which release salmonids in the Methow Watershed.

Facility Species	Stock	Number	Broodstock required	Age	Length (mm)	Location	Month
Methow FH							
Spring chinook salmon	Methow	246,000	140	1+	150	Methow	Apr-May
	Twisp	246,000	140	1+	150	Twisp	Apr-May
	Chewuch	246,000	140	1+	150	Chewuch	Apr-May
RIHC (Eastbank FH)							
Summer chinook salmon	Wells	400,000	245	1+	160	Carlton	Apr-May
Summer steelhead	Wenatchee	400,000	200	1+	195	Wenatchee	Apr-May
Wells FH							
Summer steelhead	Wells	450,000	460	1+	195	scattered	Apr-May
Winthrop FH							
Spring chinook salmon	Mixed	800,000	625	1+	170	Methow	Apr
Summer steelhead	Wells	100,000	- -[2]	1+	170	Methow	Apr

[1] *The production goal (and resultant broodstock requirements) at Methow FH and RIHC vary depending upon run strength. The values given in this table are for full production.*

[2] *Sufficient steelhead broodstock are collected at Wells Dam to supply 100,000 eggs to Winthrop NFH.*

Table F4. Current production objectives for hatcheries in the region which release salmonids in the Okanogan Watershed.

Facility Species	Stock	Number	Broodstock required	Age	Length (mm)	Location	Month
RIHC (Eastbank FH)							
Summer chinook salmon	Wells	576,000	353	1+	160	Similkameen	Apr-May
Cassimer Bar FH							
Sockeye salmon	Okanogan	200,000	344	0+	120	Osoyoos Lake	Apr-May
Wells FH							
Summer steelhead	Wells	50,000	- -[a]	1+	170	Similkameen	Apr
Summer steelhead	Wells	50,000	- -[a]	1+	170	Okanogan	Apr

[a] *Steelhead are collected at Wells Dam and used as a common broodstock for several programs within the Mid-Columbia Region. The actual broodstock needs for a given program cannot be determined.*

Appendix F, continued.

Table F5. Current production objectives for hatcheries which release anadromous and resident salmonids in the mainstem Columbia River.

Facility Species	Stock	Number	Broodstock required	Age	Length (mm)	Location	Month
Colville FH							
Rainbow trout	Tokul	660,500	- -	0 - 1+	75 - 200	various	Apr - Oct
Brook trout	Owhi	588,000	- -	1+	75 - 100	various	May - Oct
Cutthroat trout	Omak	210,000	- -	1+	110	various	May - Oct
Wells FH							
Summer chinook salmon	Wells	320,000	532	1+	160	Wells FH	April
	Wells	484,000		0	80	Wells FH	June
Turtle Rock							
Summer chinook salmon	Wells	200,000	1,045	1+	160	Turtle Rock	April
	Wells	1,620,000		0	95	Turtle Rock	June
Priest Rapids							
Fall chinook salmon	Priest Rapids	5,000,000	6,102	0	95	Priest Rapids	June
Ringold Springs							
Spring chinook salmon	Mid-Columbia	1,100,000[b]	500	1+	180	Ringold	April
Steelhead	Wells	180,000[b]	- -[a]	1+	200	Ringold	April, May

[a] *Steelhead are collected at Wells Dam and used as a common broodstock for several programs within the Mid-Columbia Region. The actual broodstock needs for a given program cannot be determined.*

[b] *All fish produced at Ringold Springs FH are released downstream of Priest Rapids Dam.*

Appendix G: Fish cultural parameters and standards for existing hatcheries in the mid-Columbia Region.

Table G1. Survival standards established through IHOT, and actually met, for selected taxa in mid-Columbia Region. The numbers in parentheses indicate the years of available data.

Species / Stock	Prespawn survival (%) Standard	Prespawn survival (%) Actual	Prespawn survival (%) Proposed	Fertilization to release survival (%) Standard	Fertilization to release survival (%) Actual	Fertilization to release survival (%) Proposed
Spring chinook salmon						
Chiwawa	78.4	97.7 (2)	95.0	65.0	84.5 (5)	86.0
Methow	80.0	93.8 (3)	95.0	59.5	92.5 (3)	86.0
Leavenworth	98.0	97.3 (5)	98.0	85.7	85.0 (5)	86.0
Entiat	95.0	95.6 (5)	96.0	85.7	82.3 (5)	86.0
Winthrop	95.0	96.2 (5)	96.0	85.7	75.6 (5)	86.0
Summer chinook salmon						
Dryden	78.4	87.7 (4)	85.0	65.0	79.6 (5)	80.0 (1+)
Wells	78.4	93.7 (4)	85.0	65.0	75.2 (5)	80.0 (1+)
Rocky Reach	- -	- -		81.0	83.7 (5)	83.0 (0+)
Fall chinook salmon						
Priest Rapids	90.0	93.3 (5)	93.0	81.0	88.2 (5)	83.0
Summer steelhead						
Eastbank	- -	- -		81.0	82.4 (5)	83.0
Wells	- -	98.3 (5)	95.0	81.0	83.1 (5)	83.0
Sockeye salmon						
Wenatchee	78.4	81.0 (5)	85.0	65.0	81.6 (5)	83.0
Okanogan		72.0[a]		80.0[a]		80.0

[a] *Based on information in broodstock protocol.*

Table G2. Water and space requirements and constraints for existing acclimation ponds in mid-Columbia Region.

Site	Capacity (pounds)	Pond size (cf)	Capacity index (p/cf)	Water use (cfs)	Flow index (p/cfs)	Over-winter
Chiwawa	56,000	75,000	0.75	21.0	2,667	yes
Dryden	86,400	115,200	0.75	32.2	2,683	no
Carlton	40,000	53,400	0.75	14.9	2,685	no
Similkameen	57,600	77,000	0.75	21.4	2,692	yes
Twisp	16,400	20,000	0.82	5.6	2,929	no
Chewuch	16,400	20,000	0.82	5.6	2,929	no
Methow	18,000	24,000	0.75	5.6	2,929	yes

Appendix H. Proposed environmental monitoring of facilities in the Mid-Columbia Hatchery Program.

Environmental monitoring will be conducted at Mid-Columbia Hatchery Program facilities to ensure these facilities meet the requirements of the National Pollution Discharge Elimination Permit administered by the Washington Department of Ecology. It is also used in managing fish health. On a short-term basis, monitoring helps identify when changes to hatchery practices are required. Long-term monitoring provides the ability to quantify water quality impacts resulting from changes in the watershed (e.g., logging, road building and urbanization). The following parameters will be monitored at all Mid-Columbia hatcheries:

- *Total Suspended Solids (TSS)*—1 to 2 times per month on composite effluent, maximum effluent and influent samples. Once per month on pollution abatement pond influent and effluent samples.
- *Settleable Solids (SS)*—1 to 2 times per week on effluent and influent samples. Once per week on pollution abatement pond influent and effluent samples.
- *Upstream and Downstream Temperatures*—twice per month, June through September.
- *Upstream and Downstream Dissolved Oxygen (DO)*—twice per month, June through September.
- *In-hatchery Water Temperatures*—maximum and minimum daily.
- *In-hatchery Dissolved Oxygen*—as required by steam flow or weather conditions.
- *Influent Water Temperatures*—continuous monitoring
- *Air Temperatures*—continuous monitoring
- *Influent/Effluent Dissolved Oxygen*—continuous monitoring
- *Influent pH/Conductivity*—continuous monitoring
- *Streambed Movement*
- *In-stream Flow/Current*
- *Daily Rainfall*

Records will be kept in a consistent manner employing standard formats to allow for documentation and monitoring. Future record keeping will be coordinated with the basin-wide Coordinated Information System (CIS) currently under development. The CIS development is being funded by Bonneville Power Administration. It will include basic biological data for cultured fish, natural populations, habitat and system parameters.

Appendix I. Proposed Fish Health Management Program for all stocks in the Mid-Columbia Hatchery Program

The primary objective of fish health management programs at the Mid-Columbia hatcheries is to produce healthy smolts that will contribute to the fisheries and natural spawning. Equally important is to prevent the introduction, amplification or spread of certain fish pathogens which might negatively affect the health of both hatchery and naturally reproducing stocks. The Mid-Columbia hatcheries will implement both disease control and disease prevention programs to achieve these objectives. These programs include the following standard elements:

Disease Control (Reactive)

- Perform necropsies of diseased and dead fish to diagnose the cause of loss.
- Prescribe appropriate treatments and remedies to disease.
- Use a disease control policy which dictates how specific disease problems will be addressed and what restrictions may be placed on movements of diseased stocks.
- Conduct applied research on new and existing techniques to control disease epizootics.

Disease Prevention (Proactive)

- Routinely perform necropsies of clinically healthy fish to assess health status and detect problems before they progress to clinical disease or mortality.
- Implement disease preventative strategies in all aspects of fish culture to produce a quality fish. This includes prescribing the optimal nutritional needs and environmental conditions in the hatchery rearing container based on historical disease events. It also involves the use of vaccines or antibiotics prophylactically in order to avoid a disease problem.
- Use a disease prevention policy which restricts the introduction of stocks into a facility which may result in the introduction of a new disease condition or mortality.
- Use sanitation procedures which prevent introduction of pathogens into and/or within a facility.
- Conduct applied research on new and existing disease prevention techniques.
- Use pond management strategies (e.g., Density Index and Flow Index) to help optimize the quality of the aquatic environment and minimize fish stress which can induce infectious and noninfectious diseases. For example, the Density Index is used to estimate the maximum number of fish (of a given length) that can occupy a rearing unit based on the rearing unit's size. The Flow Index is used to estimate the rearing unit's carrying capacity based on water flows.

Health Monitoring

- On at least a monthly basis, both healthy and clinically diseased fish from each fish lot at the hatchery will be given a health exam. The sample includes a minimum of ten fish per lot.
- At spawning, a minimum of 60 ovarian fluids and 60 kidney/spleens will be examined for viral pathogens from each fish lot.
- Prior to transfer or release, fish will be given a health exam. This exam may be in conjunction with the routine monthly visit.
- Whenever abnormal behavior or mortality is observed, the fish health specialist will examine the affected fish, make a diagnosis and recommend the appropriate remedial or preventative measures.
- Reporting and control of selected fish pathogens will be conducted in accordance with the Co-Managers Fish Disease Control Policy.

Fish and Egg Movements

- Movements of fish and eggs will be conducted in accordance with the Co-Managers Fish Disease Control Policy.

Therapeutic and Prophylactic Treatments

- Adult fall chinook will be injected with antibiotics for the control of bacterial diseases.
- At spawning, eggs will be water-hardened in iodophor as a disinfectant.
- Juvenile fish will be administered antibiotics orally when needed for the control of bacterial infections.
- Formalin (37% formaldehyde) is dispensed into water for control of parasites and fungus on eggs, juveniles and adult salmon. Treatment dosage and time of exposure varies with species, life-stage and condition being treated.
- Only therapeutants approved by the U.S. Food and Drug Administration will be used for treatments.

Sanitation

- All eggs brought to the facility will be surface-disinfected with iodophor (as per disease policy).
- All equipment (nets, tanks, rain gear) is disinfected with iodophor between different fish/egg lots.
- Different fish/egg lots will be physically isolated from each other by separate ponds or incubation units. Incubation units will be further isolated by plastic curtains. The intent of these activities is to prevent the horizontal spread of pathogens by splashing water.
- Tank trucks will be disinfected between the hauling of different fish lots.
- Foot baths containing iodophor will be strategically located on the hatchery grounds (i.e., entrance to “clean” or isolated areas of the incubation room) to prevent spread of pathogens.

Appendix J: Typical Broodstock Collection Protocols for the Mid-Columbia Hatchery Program

J.1: Summer/Fall Chinook Salmon

J.1.1: Methow and Okanogan rivers

This section provides guidelines for collection of summer chinook broodstock from the east fishway at Wells Dam and for volunteers to Wells FH. Guidelines are based upon natural escapement goals for the Methow and Okanogan/Similkameen drainages, and broodstock requirements of summer chinook for the Wells, Eastbank, and Rocky Reach fish hatcheries. An action plan has been developed to adjust collection of broodstock from the trap to account for shifts in run timing or the potential for low escapement of natural spawners.

Chinook salmon broodstock for Wells FH has routinely been collected primarily from volunteers to the hatchery, and secondarily from the fishways at Wells Dam. Trap operation on the west fishway posed some difficulties however, for maintenance of stock integrity for the hatchery. Most (80%) of the summer chinook adults passing Wells Dam enter the east fishway, making broodstock collection on the west fishway time consuming. Trap operations often had to continue well into late September to collect adequate broodstock. This caused problems with potential collection and spawning of fall chinook salmon (notably Priest Rapids stock) in the Wells FH production. The presence of Priest Rapids hatchery fish in the Wells FH broodstock was verified through coded-wire tag recoveries.

In 1991, a trap was built on the east fishway at Wells Dam. Summer chinook salmon are collected for broodstock at this site (primarily for the Similkameen and Carlton acclimation ponds operated by Eastbank FH, and secondarily for Wells FH). Broodstock collection has become more expedient as a result. Trap operations terminate on 28 August, which virtually eliminated all known fall chinook salmon from the Wells broodstock, as determined by subsequent coded-wire tag analyses (LaVoy 1992, 1993). In 1991 and 1992, fish were trapped on the east and west fishways; since then, only the east fishway trap was used. Prior to 1991, fish were collected on the west fishway only.

Sufficient escapement past Wells Dam is required for the Methow, Similkameen, and Okanogan Rivers. These streams are managed on a natural stock basis (NPPC 1991). The long-term escapement goals of the Integrated System Plan is to achieve Maximum Sustainable Yield; desired escapement past Wells Dam is 1,503 summer chinook for the Methow Subbasin, and 6,043 summer chinook for the Okanogan/ Similkameen Subbasin. Broodstock collection at Wells Dam is managed to balance the needs of hatcheries and natural escapement goals.

Hatchery production

Since inception of Wells FH in 1967, less than 25% of the summer chinook salmon run (adults and jacks) to Wells Dam were collected for broodstock, both as volunteers and on the west fishway. In some years however, collections included eggtake needs for Entiat and Winthrop National Fish Hatcheries. Most fish used for production are from voluntary returns to the hatchery. From 1985 to 1993, 77% of the summer chinook used at Wells FH were volunteers, although eggtake goals were not met in 1987, 1992, and 1993. LaVoy (1993) estimated that 9% of the adult summer chinook migrating through Wells Dam in 1992 were intercepted for broodstock.

The production objectives for Wells FH are to release 484,000 subyearlings in June at 20 fish per pound (fpp), and 320,000 yearlings in April at 10 fpp. To meet these goals, an eggtake of 1 million is required. The production objectives for Eastbank FH include 400,000 yearlings for release from Carlton in

April and May at 10 fpp, and 576,000 yearlings for release from Similkameen in April at 10 fpp. To meet these objectives, an eggtake of 1.2 million is required. These values are based upon 85% subyearling and 80% yearling egg-to-smolt survival rates. The average prespawning mortality at Wells FH is 12%, average male:female ratio is 1:1, and average fecundity is 4,900 eggs/female. If one million eggs are needed for Wells FH production, 457 adults need to be collected from Wells Dam and Wells FH ladder combined. For Eastbank FH production, 594 adults need to be taken from Wells Dam.

If 77% of the summers required for Wells FH can be obtained through volunteers, 106 adults (23% of 457) need to be trapped at Wells Dam for complete production. A total of 700 adults therefore, need to be trapped for Eastbank and Wells FH (106 plus 594). Average summer chinook run size to Wells Dam from 1983 to 1993 is 3,477 adults. Conceivably, 20% (700 out of 3,477) of the run would be required for hatchery production.

The objective of maximum escapement upstream of Wells Dam must be balanced with the preponderance of volunteers relative to trapped fish. Consecutive record low numbers of summer chinook salmon passed Wells Dam in 1991 (1,776 adults and 270 jacks) and 1992 (1,333 adults and 631 jacks), despite relatively strong returns of volunteers to Wells FH. Trapping was curtailed at the dam both years to increase upstream escapement, yet collections of volunteers to the hatchery continued. The result of this action was to take progeny of Wells FH volunteers for production at Eastbank FH.

Natural production

Average summer chinook escapement to the streams above Wells Dam (Methow, Similkameen, and Okanogan Rivers) can be monitored through counts at Wells Dam. This number is the primary criterion to assess broodstock collection procedures. The recent year (1981 to 1993) average summer chinook salmon (adults and jacks) per redd ratio in tributaries upstream of Wells Dam is 8.3 (Table 2). The 30-year (1961-1990) average is 9.8 salmon per redd, based upon an average escapement past Wells Dam of 6,700 adults and jacks for this period. Broodstock collection should be done to maintain escapement and redd deposition near historical levels, with a minimum escapement of 2,000 salmon (adults and jacks) above Wells Dam.

For the recent period, the correlation coefficient (r^2) between Rocky Reach Dam counts and Wells Dam counts for summer chinook (adults and jacks) is 0.74, based upon the least squares equation $y = 0.57x + 817$, with Wells Dam counts dependent upon Rocky Reach Dam counts. An escapement of 3,304 summer chinook past Rocky Reach Dam would maintain the Wells Dam escapement goal plus the broodstock collection goal (2,000 plus 700).

Action plan

The objective is to achieve highest feasible natural escapement, yet still maintain viable hatchery programs. Neither the natural escapement objective (2,000 salmon) or the broodstock collection objective (700 trapped salmon) will be met. Two objectives will be set, in order of priority:

1) Pass at least 1,400 salmon (adults and jacks) upstream for natural spawning.
2) Collect sufficient broodstock to produce 200,000 yearling smolts for the Wells, Similkameen, and Carlton programs. Based the established fecundity and survival rates, 306 salmon need to be collected (volunteers and trapped fish combined) to produce the 600,000 yearlings for the combined programs.

Table 2. Recent year indices of summer chinook spawning in the Methow, Similkameen, and Okanogan Rivers to Wells Dam counts (adapted from Langness 1991, Hillman and Ross 1992, and Peven 1992).

	Peak redd counts[1]			Wells Dam count
Year	Methow	Similkameen	Okanogan	(adults and jacks)
1981	195	121	55	4,276
1982	142	59	23	3,349
1983	65	57	36	2,821
1984	162	301	235	5,941
1985	164	300	138	4,456
1986	169	300	197	4,178
1987	211	164	201	3,142
1988	123	191	113	2,775
1989	126	221	134	3,333
1990	229	94	88	3,354
1991	120	68	55	2,046
1992	91	48	35	1,962
1993	116	152	144	3,574
Averages	147	160	112	3,477

[1] *Methods of measuring and classifying chinook salmon spawning ground counts have varied through the years, and may not be directly comparable in this table.*

No more than 700 salmon will be trapped, or no more than 20% of the run (based upon Rocky Reach Dam counts), whichever is lowest. The ten-year (1984-1993) average run size at Rocky Reach Dam is 4,412 salmon (adults and jacks). If Rocky Reach run size is less than 90% of this value (i.e., 4,000 salmon) broodstock collection should be reduced proportionally. Run size estimates for summer chinook to Wells Dam should be based upon weekly analyses of counts at Rocky Reach Dam during its summer chinook migration period (20 June to 19 August). If the cumulative summer chinook counts at Rocky Reach Dam is less than 40% of the 1984-1993 average for that given date, broodstock collections at the fishways will be terminated until the cumulative count exceeds that criterion. Under this contingency, broodstock will be collected from volunteers only, and will be used for both the Wells and Eastbank programs. Table 3 is a framework for broodstock collection at various run sizes.

Table 3. Broodstock trapping goals at Wells Dam fishway, based upon projected summer chinook run sizes at Rocky Reach Dam.

Rocky Reach run size	Trapping goal
4,000+	700
3,600 - 4,000	600 - 700
3,200 - 3,600	540 - 600
2,800 - 3,600	475 - 540
2,400 - 2,800	400 - 475
2,000 - 2,400	175 - 400[a]

[a] *At low levels of Rocky Reach escapement, trap operations at Wells Dam should be adjusted to meet minimum escapement goal (2,000 salmon).*

Run timing cutoff dates for summer chinook at Wells Dam is 28 June to 28 August. The east trap will be operated two days a week during this period. If run strength is equal each day of the week, trap efficiency on the east fishway should approximate the 20% criterion (2 days/week x 80% of run on the east fishway= 22%). All trapping will be on the east fishway. The west fishway will be maintained however, in case difficulties in the east trap occur. All fish will be marked when trapped to discern them from volunteers.

Jacks will be taken in the same proportion and timing as found in the run at large. Marked (adipose-clipped) salmon will be retained for broodstock, because of four factors:

(1) The contribution of hatchery salmon to the natural spawning population is probably negligible at this early stage in the Eastbank Program.
(2) The information on survival of smolts released from the Carlton and Similkameen acclimation ponds is necessary to make informed decisions on hatchery management.
(3) Not all hatchery salmon are marked.
(4) Separation of unmarked and marked salmon at the trap requires additional handling, increasing stress to the fish.

Hatchery volunteers will be collected from 1 July to the end of spawning in November; all volunteers will be retained for broodstock. Broodstock for Wells FH will be primarily from volunteers, and secondarily from some component derived from the run at large at Wells Dam. Gametes taken to Eastbank FH may be the progeny of volunteers to Wells FH, yet the long-term strategy is for the Eastbank Program to rely solely upon trapped fish for broodstock. If a preponderance of salmon volunteer to the hatchery, the number of salmon trapped in the east fishway should be reduced accordingly.

Spawning and egg allocation

Spawning occurs at Wells FH from mid-October through mid-November. Based upon coded-wire tag recoveries, some fall chinook salmon are spawned throughout the eggtake, but most are spawned in November. Salmon spawned after 1 November will be used for the Rocky Reach Program. Eggs will be allocated between the Wells FH and Eastbank FH programs weekly from 1 October through 31 October.

If the collection objective of 306 salmon is not met, egg allocation will be divided equally between the three programs. If more than 306 adults are collected, the additional eggtake will supplement the Wells yearling program. If less than 230 salmon are collected (which would produce 450,000 yearlings), production at Similkameen would be eliminated, and eggs would be divided equally between Wells and Carlton.

Eggs will be fertilized on a one female to one male basis, with a timed male backup. Each family will be incubated separately. Coded-wire tags of marked salmon will be read either during spawning or during incubation; all efforts will be made to remove coded-wire tagged chinook salmon from nonlocal hatcheries from the Wells and Eastbank Programs.

Concerns for other migrating fish

Summer chinook salmon migration to the Wells Project is generally June 28 to August 28. Between these dates the entire Okanogan sockeye salmon run and the first third of the summer steelhead run also use the fishways at Wells to reach spawning grounds. To reduce delays for these migrating fish, the sorting flume will be staffed at all times while the fishway is barricaded for the purpose of guiding fish into the trap. The trap will be operated in a manner to reduce retention time in the holding pool above the denil fishway. Attraction flows from the false weir will be maintained to encourage fish to use the sorting flume. Fish not required for broodstock will be returned into the fishway as they move through the sorting flume to continue their migration. This will minimize the delay of those fish not needed for broodstock.

J.1.2: Wenatchee River

Average escapement of summer chinook salmon to the Wenatchee River since 1960 is 9,100 adults and jacks (SD= 3,100). This estimate is based upon the difference in counts between Rock Island and Rocky Reach dams from 24 June to 1 September. Peak of spawning for summer chinook is 1 to 15 October , and varies by river location (upstream salmon spawn earlier than downstream salmon). Little information is known about migration timing in Wenatchee River, however.

Summer chinook salmon are produced at Eastbank Fish Hatchery (FH) as part of the Rock Island Settlement Agreement. The production goal of the Wenatchee summer chinook program is 864,000 smolts at 10 fish per pound. Since 1991, all Wenatchee summer chinook salmon have been marked (CWT and adipose clip). To meet this program, 453 adults are required, based upon an adult sex ratio of 1.0:1.0, average fecundity of 5,200, prespawning survival of 90%, and fertilization to release survival of 80%. On an average return year, about 5% of the summer chinook run would be collected for broodstock. Adults are held and spawned at Eastbank FH; progeny are incubated and reared there and transported to Dryden Acclimation Pond for release as yearling smolts. Primary broodstock collection point is Dryden Dam (located at RK 24.9), secondary point is Tumwater Dam (RK 52.8).

Dryden Dam There are two fishways with upstream migrant traps at Dryden Dam, both are located on the banks. The right bank trap is the primary broodstock collection facility. It has a steep pass structure to transfer adults into a holding box, which can be carried by gantry to a tank truck. Fish can be transferred without handling. An inflatable dam was built on the right bank sill to increase trap efficiency; when the dam is inflated, flow is displaced through the right and left fishways. There is potential for adult and juvenile salmonid stranding immediately below the dam during inflation, and there is potential for stranding downstream of the center and left legs of Dryden Dam during deflation. Captured fish show no obvious stress and negligible prespawning mortality, and fish passed upstream for natural spawning are apparently not delayed.

The left bank trap is capable of collecting all large upstream migrants that pass the left bank fishway. Bar spacing in the trap is 5 cm. It contains a false bottom, which can be raised to collect trapped fish with a dip net. There are three concerns over extensive use of this trap: (1) the trap may be a safety hazard to hatchery staff, (2) smaller fish may be able to pass through the bars of the trap, causing potential for selectivity based upon size, and (3) sockeye salmon run timing overlaps with summer chinook salmon--extensive trapping efforts on the left bank trap may delay sockeye salmon passage.

Tumwater Dam A trap on the left bank of Tumwater Dam is capable of collecting all upstream migrants; it was built primarily for Wenatchee sockeye salmon broodstock collection. In previous years, up to 25% of the summer chinook broodstock has been collected at Tumwater trap. This standard was made to be consistent with the proportion of Wenatchee River redds observed upstream of the dam. Since 1963, the proportion of redds observed upstream of Tumwater Dam, relative to the lower river, has steadily increased. Redds counted upstream of Tumwater Dam from 1986 to 1993 comprised about 25% of total system redds.

Considerations/constraints

Concerns for other migrating fish Sockeye salmon pass Dryden Dam at roughly the same time as chinook. The 1986 to 1993 average sockeye run size in Wenatchee River is 24,000 (SD= 8,000). The proportion which pass Dryden Dam through the fishways is unknown, but it is sufficient to cause concern over their delay when trapping chinook.

Inflatable dam operations Operation of the inflatable dam may affect aquatic resources in the reach immediately downstream of Dryden Dam: 1) dewatering of the stream may strand fish in pocket waters, and 2) rapid changes in stream flow during inflatable dam operation may delay migration of salmon. These impacts are eliminated when the trap is kept inflated.

Action Plan
Broodstock collection Only unmarked salmon will be kept for broodstock. Some hatchery -origin salmon will be unmarked however, and may therefore be inadvertently collected. No effort will be made to remove unmarked hatchery salmon from the broodstock. Marked fish will be counted and passed upstream for natural spawning. This objective will require some changes in the right bank fishway and steep pass. In all years, jacks (less than 55 cm fork length) will be collected in the same proportion they appear in the run at large.

The current limit to Tumwater Dam collections (25% of total broodstock) will be maintained. This standard is to be based upon total number of fish collected, rather than the collection goal. Fish will be collected at Tumwater Dam no earlier than 16 July. Depending upon success of the Dryden Dam trap, and the stock profile analysis of the Wenatchee summer chinook salmon stock, trapping at Tumwater Dam may be phased out.

To collect salmon throughout the assumed duration of the run, trapping will be broken into six periods, starting in July. Within each period, a maximum number of salmon may be collected at Dryden and Tumwater dams. These numbers are based upon an assumed distribution in run timing past Dryden Dam. They may be modified in season when more information is available. Collections in a given trap period can be made in as few days as possible, and will be decided by the Eastbank FH manager as the season progresses. The left bank trap at Dryden will not be used, unless the hatchery staff has difficulties in collection at the right bank trap. The following table sets the trap schedule:

Trap Period	Dryden Dam	Tumwater Dam
5 July to 15 July	60	0
16 July to 31 July	170	60
1 August to 15 August	80	20
16 August to 31 August	25	0
1 September to 15 September	20	0
16 September to 15 October	18	0

Inflatable dam operations Operation of the inflatable dam will be kept at a minimum, to reduce potential impacts to salmon near Dryden Dam. Duration of the deflation period will be 24 hours or more. The dam will not be inflated more than once a week, to ensure a stable flow pattern exists. If enough salmon are collected to meet requirements for the given trap period (i.e., the target collection goal is met in one day), the hatchery crew will deflate the dam until the next trap period begins.

Fertilization methods The following strategy will be used to fertilize Wenatchee summer chinook salmon:

(1) breed as many parents as is feasible;

(2) mate at least one male per female in daily matings; whenever possible, split the gametes of the least numerous sex into subsets and cross each subset with gametes from a different individual of the more numerous sex;

(3) live spawn males, and mark them after their use.

J.2: Spring Chinook Salmon

<u>J.2.1: Chiwawa River</u>

Background

This document provides guidelines for collection and spawning of Chiwawa River spring chinook salmon for the Rock Island Fish Hatchery (FH) Complex. Eastbank FH is the central adult holding and spawning facility for Chiwawa broodstock. Incubation and initial rearing is done at Eastbank FH. Releases are from two paired acclimation ponds located near the weir on the lower Chiwawa River.

Broodstock are collected on Chiwawa River next to the satellite facility 1 km upstream of the Wenatchee River confluence. The hatchery staff operated a floating weir from 1990 through mid-season of 1992, and did not successfully capture salmon. In 1993, the trap facility was rebuilt upon the existing concrete sill that transects the river. The new structure has fixed panels held upright by hydraulic rams. In 1993, collection efficiency improved: 106 salmon were collected for broodstock and 211 were passed upstream for natural spawning. There was evidence however, that the weir impeded passage and displaced fish to Nason Creek and the Wenatchee River. The trap was therefore modified in 1994 to facilitate fish passage. Additionally, the trap was lowered periodically in the 1994 collections. On average, it was raised three out of every five days. Fifteen salmon were collected for broodstock.

Broodstock are immediately trucked to Eastbank FH, where fish are held and spawned. The trap must serve three functions: 1) collect all sizes of salmon throughout the duration of the run, 2) when not collecting broodstock, the trap must pass fish upstream with minimal delay, and 3) allow hatchery staff to classify fish by origin (natural versus hatchery), and decide which fish to collect, or pass upstream.

The Chiwawa Program requires 400 adults for full production. This is based upon assumed eggtake and smolt production requirements of 900,000 and 672,000 (at 12 fish per pound), respectively, but may be modified to reflect actual survival rates. Broodstock collections began in 1989; the first year of adult (age 3+) returns from hatchery releases was 1992. The 1984-1993 average redd deposition by spring chinook in Chiwawa River is about 300 redds. Therefore, average escapement for this period is probably 600 to 1,500 salmon, based upon a range of 2 to 5 fish/redd. There were 82 redds in 1994, which expands to an escapement of 200 to 400.

Considerations/constraints

<u>Run size:</u> The pre-season estimate on the Chiwawa River escapement is 120. This estimate will be refined during the season by multiplying the Tumwater Dam count by the ten-year average proportion of redds upstream of Tumwater Dam that are found in the Chiwawa River.

Run timing: We do not know what the Chiwawa spring chinook run timing is. Based upon trap results from previous years, it appears the modal time of entry to the Chiwawa River is in June, yet fish enter the river through mid-September. Chinook salmon will be counted as they pass Tumwater Dam with a remote video cassette recorder. The dam is 26 km downstream of the Chiwawa weir. It appears salmon reach Tumwater Dam about mid-May, with passage at the dam impeded by higher flows. Transfer of information on salmon passage through Tumwater Dam will aid Chiwawa FH staff in collection efforts. Subsets of the tapes will be read by Chelan PUD to gain a rough index of passage.

Action plan
Broodstock collection: The Chiwawa trap protocol is based on four guidelines:

1) On a systematic schedule from June through mid-September, the weir panels will be raised for five days, then lowered the following day.
2) No more than 30% the estimated run of all natural-origin salmon to the Chiwawa River will be collected for broodstock.
3) Every other natural-origin salmon that is trapped will be passed upstream. A larger proportion will be passed upstream if it appears that more than 30% of the estimated run is being collected. Collections will consist of natural salmon in proportion to the population's run timing and age structure.
4) Hatchery-origin salmon will not be collected.

The weir will be operated to minimize delays or displacement of salmon. Therefore, this trap schedule may be changed during the season to seek an appropriate balance between the collection goal (30% of the run) and good passage conditions. Staff from WDFW will periodically snorkel the Chiwawa River from the weir to the confluence and the Wenatchee River from the hatchery intake to the Chiwawa River. The purpose of these surveys is to investigate holding and passage of salmon. Fertilization methods will be determined in late summer when a firm estimate of broodstock size and sex ratio is available.

J.2.2: Methow River spring chinook salmon
Background

Methow Fish Hatchery (FH) was designed to propagate three spring chinook salmon stocks, from the Methow, Chewuch, and Twisp rivers. The hatchery's production goal varies yearly with run strength; maximum production for each stock is 250,000 yearlings at 15 fish per pound. Broodstock required to meet this level of production is 190 spawners (95 ♂ and 95 ♀) per stock, based upon a fecundity of 4,400 and 1:1 sex ratio. Assuming an 80% prespawning survival, 238 salmon need to be collected for full production.

Methow River: The long-term goal is to collect the founder population for the Methow stock at Foghorn Dam, which is expected to be capable of trapping in fall 1995. The Methow FH outfall channel, which has flows up to 20,000 L\min, is capable of attracting salmon volunteers. In 1993, the hatchery crew collected 99 of these salmon for Methow production in an attempt to establish a founder population. Scale pattern analysis however, indicated that 67% of these appeared to be of hatchery origin, most likely from Winthrop FH. In 1994, 17 salmon were collected, of which 14 appeared to be of hatchery origin.

Chewuch River: Broodstock are collected at a trap on the Fulton irrigation diversion dam on the Chewuch River, which has had variable trap efficiency. Broodstock collections began in 1992, when 33 salmon were trapped, of which 20 were retained. Based upon redd count expansions, about 10% of the spawners was collected. In 1993, 186 salmon were trapped, and 110 were retained, comprising about 30% of the spawning population. In 1994, ten salmon were collected.

Twisp River: Broodstock are collected at a floating weir facility on the Twisp River. It has had a low trap efficiency. Also there have been concerns that the weir delays upstream passage, and does not collect a representative sample of the population. In 1992, 71 salmon were captured; 30 of which were retained for broodstock. An undetermined, but presumably large number of salmon passed the weir in moderately high flow. It appears that over 300 salmon spawned in the Twisp River in 1992, based upon redd count expansions. Based upon this estimate, the hatchery crew trapped 25% of the spawning population, and retained 10% or less for broodstock. In 1993, hatchery staff trapped 70 salmon and retained 42, which appears to be about 25% of the spawners, based upon redd count expansions. In 1994, five salmon were collected.

Historical Escapement

The 1984-1993 average Wells Dam counts for spring chinook salmon is 2,274 (adults and jacks). The typical distribution of redds is 45% Methow River, 28% Chewuch River, and 27% Twisp River. Escapement to these streams (based on spawning ground surveys in index areas) appears to be quite variable. This variation should be considered in yearly broodstock collection plans; fewer fish should be collected in years of low abundance.

Several concerns have been raised over the low effective breeder size in the Methow FH in 1994. These concerns were attributed to a small number salmon in the broodstock, unequal sex ratio, differential rates of maturation, and the division of the number of spawners into distinct mating pools. To mitigate these problems, adults will be collected at Wells Dam for broodstock.

The advantages of collecting broodstock at Wells Dam are: 1) the hatchery crew can collect fish throughout the duration of the run in a manner that is safe to the fish, 2) the potential for delays or displacement at the terminal area traps will be alleviated, 3) a higher proportion of the run will be placed in a hatchery, giving them a survival advantage over naturally-produced salmon, 4) prespawning mortality may be reduced, and 5) the effective population size will be increased. The disadvantage of collecting broodstock at Wells Dam is that efforts to encourage local adaptation of the three distinct populations will be negated for one year (or more, if the decision is made to collect at Wells Dam in future years). Given the critically low run size expected in the immediate future, the advantages of trapping at Wells Dam outweigh the disadvantage.

Action Plan

The established spring chinook run timing at Wells Dam is 1 May to 28 June. During this period, the east ladder trap will be operated three days a week (43% trap period). The collection goal will be 80 salmon, or 25% of the run, whichever is fewer. Methow FH would therefore operate at 10-15% of capacity. Only unmarked salmon will be collected; all adipose-clipped salmon will be released upstream. Salmon will be immediately transferred to the tank truck, and will be transported to Methow FH at least twice a day. Guidelines will be established for tank loadings and duration .

Scale samples from the broodstock will be taken during collection, and analyzed prior to spawning, for freshwater growth patterns and rare earth composition. The latter technique will be used, on a probability estimate, to assign a fish to a given stock. If the scale pattern indicates a salmon is hatchery-origin, the fish will be assigned to the Methow stock (which would include Winthrop FH). Logistics of this transfer will be determined by the hatchery managers.

The crews at Methow and Winthrop FHs will monitor the numbers of spring chinook salmon that volunteer into both facilities. These fish will be included in the hatcheries' broodstock. If a significant number of salmon volunteer into the channel or hatchery, collections at Wells Dam will be reduced accordingly.

To maximize genetic diversity, all salmon will be spawned as one population, unless some segregation is feasible from interpretation of the scale data. At this time, the strategy will be to divide the gametes equally among the four stations (Methow, Winthrop, Chewuch, and Twisp), although this strategy may be revised when firm estimates of broodstock size, and volunteer rate are known. Likewise, fertilization methods will be determined in late summer when the broodstock size and sex ratio are known.

J.3: Steelhead

This protocol set interim directions for collection of steelhead in a manner that encourages local adaptation and integration of natural and hatchery origin fish. These guidelines will be adjusted periodically as the recovery program is underway. Under Phase A of the Mid-Columbia Hatchery Program, marked and unmarked steelhead will be collected from the run at large, without selection, from the central 80th percentile of the run at the trapping locations.

J.3.1: Wells Dam

The total target collections for Wells Dam is 420 mixed marked and unmarked fish from the run at large, spaced throughout the time period (approximately the 80th percentile). This steelhead broodstock will be held and spawned at Wells FH to satisfy production requirements for the Methow and Okanogan basins and at Ringold FH (no wild fish progeny will be transferred to Ringold). All adult steelhead collected at Wells Dam will be uniquely marked with a VI tag to determine the relation between arrival time and maturation time. All Wells trapped steelhead will be sampled for age and growth analysis, and fish health assessment. A representative group of fish will be sampled for genetic stock identification.

The broodstock will be split into the Okanogan, Methow, and Ringold production groups as follows:

Okanogan Basin	Wells stock	included with Wells Dam west ladder collections
Methow Basin	Wells stock	trap 420 mixed (run at large) steelhead in west ladder trap at Wells Dam.
Ringold	Wells stock	included with Wells Dam west ladder collections

J.3.2: Wenatchee River

Dryden Dam: The trap will be operated from 1 July to 14 November, five days/week. Passive operation 24 hours a day, and checked daily in early morning. Run denil up to 3 hours as necessary to ensure fish movement from the trap. The collection target is 100 unmarked and 128 marked combined with Tumwater Dam collections. Steelhead broodstock will be held and spawned at Eastbank FH.

Tumwater Dam The trap will be operated from 9 June to 14 November, three days/week. Active operation 16 hours a day. Maintain set schedule. Steelhead target 100 unmarked and 128 marked when combined with Dryden Dam collections. Hold and spawn at Eastbank FH.

The broodstock will be split into the Wenatchee and Entiat production groups as follows:

Wenatchee Basin	Wenatchee stock	trap 100 unmarked and 128 marked steelhead at Dryden and Tumwater dams
Entiat Basin	Wenatchee stock	included with Wenatchee marked fish collection which are Wells stock lineage

J.4: Sockeye Salmon

J.4.1: Wenatchee River

This protocol sets guidelines for collection of sockeye salmon at Tumwater Dam for production by Eastbank FH. Tumwater Dam is located at river kilometer 52 on the Wenatchee River. The production objective is to release 240,000 sockeye salmon in July through November 1994. This requires 300 adults for broodstock. The 1982-1991 average sockeye salmon run size to Wenatchee River is 32,160 (s=14,275), based upon the difference between Rocky Reach and Rock Island Dam counts. Less than one percent of the run is therefore collected for broodstock. The escapement goal for sockeye salmon upstream of Tumwater Dam is 23,000, so it is not limited by broodstock collections.

Action plan

Fish will be trapped from the middle 80th percentile of the run-at-large, to ensure adequate genetic diversity. To accomplish this goal, sockeye salmon will be trapped over an eight-day period during the peak of Tumwater Dam counts, which generally encompasses the middle 80th percentile. If the peak is protracted, trapping will be done in a manner that is proportional to daily passage at the dam. Typically, the peak of counts at Tumwater Dam are 12-20 days after the peak at Rock Island Dam, which is used as an indicator of run timing in Wenatchee River. Trapping at Tumwater will start at least eight days after the estimated peak of sockeye salmon passage at Rock Island Dam, or 15 July, whichever occurs first. Collections should begin when the hatchery crew determines that a substantial number of sockeye salmon are passing Tumwater Dam. To reduce the potential for adverse effects on natural production, the following guiding principles to broodstock collection will be adhered to:

(1) No more than 10% of the entire run will be collected for broodstock.

(2) Fish will be trapped from the middle 80th percentile of the run-at-large, to ensure adequate genetic diversity. If the run duration is protracted, trapping will be done in a manner that is proportional to passage distribution at Tumwater Dam.

(3) Age classification of sockeye salmon is not feasible using length as a criterion. A random collection of fish during the peak of passage at Tumwater Dam ensures proportional representation of the age structure. No attempts should be made to collect a given size fish.

(4) The broodstock should contain no more than 10% of the marked (hatchery-origin) salmon in the total collections, although efforts will be to use no hatchery fish.

Based upon a comparison of age composition of salmon collected for broodstock with those studied on the spawning grounds, it appears that fish collected at Tumwater Dam are representative of the age structure of the population. All salmon released from this program will have external marks, enabling their recognition upon return as adults. In future years, sockeye salmon may be collected at Dryden Dam, rather than Tumwater Dam. The Eastbank FH crew may trap 20 or fewer sockeye salmon at Dryden to test the feasibility of using this facility. If done, these fish will be included as part of the collection goal.

J.4.2: Okanogan River

The protocol outlined below provides guidelines for collection of sockeye salmon at the east ladder of Wells Dam for propagation at Cassimer Bar FH. Trap operations will be coordinated with the concurrent collections for summer/fall chinook salmon at that facility. Daily ladder counts at Wells Dam indicate a historical run pattern for the middle 80th percentile of the run at large occurs during a 40 day period between 8 July and 16 August. The trap will be operated two days a week; passage will not be impeded the remaining five days. The following guidelines will be used:

(1) No more than 10% of the entire run will be collected for broodstock, to reduce potential for deleterious impacts to natural production.

(2) Fish will be trapped from the middle 80th percentile of the run-at-large, to ensure adequate genetic diversity. If the run duration is protracted, trapping will be done in a manner that is proportional to passage distribution at Wells Dam. Broodstock collection will parallel the relative strength of weekly returns.

(3) Age classification of sockeye salmon is not feasible using length as a criterion. A random collection of fish during the peak of passage at Wells Dam ensures proportional representation of the age structure. No attempts should be made to collect a given size fish.

(4) The broodstock will contain no more than 10% of the marked (hatchery-origin) salmon in the total collections.

(5) Sockeye salmon collections will work in concert with summer chinook salmon collections; passage will be allowed at all times when the trap is not in operation.

Appendix K: Assessing Reproductive Success of Hatchery and Natural Fish in the Natural Environment Using DNA Profiling to Reconstruct Pedigrees.

A key unanswered question regarding the use of supplementation is the productivity of hatchery fish and their descendants in the natural environment. This issue is a central factor in determining the success of programs to assist weak or declining natural populations. It is also essential in evaluating the long-term consequences of mixing hatchery production with currently healthy natural populations.

To address this critical issue, the Mid-Columbia Hatchery Program could include a genetic monitoring program designed to directly measure the productivity of individual hatchery and natural fish in natural habitat. A major component of this program would involve collection of non-lethal tissue samples (e.g., a small fin clip) of all or a subset of the natural spawners (both returning natural fish and hatchery fish) in a particular area. The progeny of these spawners would be similarly sampled at one or more life stages up to and including returning adults. By scoring both parents and progeny at a number of highly polymorphic DNA loci, it is possible to determine which progeny were produced by which parents, and this measure the reproductive success of each individual spawner. This method does not rely on the existence of genetic differences between the natural and hatchery populations; rather, it takes advantage of the enormous store of genetic variation among individuals. From these data, one could then compare the productivity of various categories of fish (eg., H x H, H x N, N x N) or among various age classes. By continuing this monitoring program for two or more salmon generations, the environmental and genetic effects of artificial propagation natural productivity could also be teased apart.

The choice of species and location for the experiment should be based on the logistical constraints discussed below:

Number of potential parents: The number of potential parents (e.g., a distinct spawning aggregation) is important in determining the number of loci that will be needed in order to accurately reconstruct pedigrees. In theory sufficient genetic variation exists among individuals to determine familial relationships nearly unambiguously for essentially any number of potential parents and offspring. Logistically, however, it is likely to become more difficult to unambiguously determine pedigrees as the number of potential parents grows very large. Busack (WDFW, pers. comm.) has written a computer program to estimate the ability to determine pedigrees as a function of the number of potential parents and progeny, number of loci scored, and the distribution of allele frequencies at each locus. With realistic allele frequencies and reasonable numbers of loci, a large fraction of progeny can be assigned unambiguously to unique pairs of parents, even when potential parents number in the thousands. Logistical constraints of collecting and accurately scoring large numbers of individuals may effectively limit the number of potential parents to less than several thousand, however.

The number of potential parents also plays a large role in determining the statistical power of the experiment to detect differences among categories of spawners (e.g. hatchery or wild). A preliminary power analysis based on the observed variance in reproductive success among coho salmon in an experimental spawning channel suggests that spawning population sizes of several hundred may be needed to have a high probability (> 0.8) of detecting a 50% difference in reproductive success among groups at a p-value of 0.5 (Hard, NMFS, pers. comm.). To a have a high probability of detecting small differences (e.g. less than 10%), spawning population sizes may need to be in the thousands.

Fraction of potential parents sampled: This is an important and at this time unexplored parameter. If only a small fraction of the potential parents are sampled, then there will probably be a large number of progeny that cannot be assigned to parents. It is also possible that progeny could be assigned to the wrong parents. C. Busack (WDFW, pers. comm.) is quantitatively exploring the effects of varying this parameter, and his results will be used to determine what fraction of the potential parents will need to be sampled. At this time, however, it is prudent to assume that a large fraction of the potential parents will need to be sampled in order to successfully conduct the experiment.

Number of progeny and life-story stages sampled: Sampling progeny at several life-history stages may provide considerably more useful information than sampling at only a single life-history stage. For example, by sampling eyed-eggs, parr, smolts and returning adults, the reproductive success of hatchery fish in the natural environment could potentially be explored at numerous levels, including spawning, freshwater rearing and migration, ocean rearing and return migration. Some intermediate life-stage sampling may also be useful for addressing other questions, including determination of the relative importance of genetic and environmental components of phenotypic variation for life history traits that affect reproductive success and possibly measuring stray rates.

After discussing these and other issues the HWG concluded that using this approach to assess the reproductive success of hatchery and wild spring chinook above Tumwater Dam would be logistically feasible for study during Phase A of the MCHCP. This conclusion was based on the following considerations: 1) The trap at Tumwater Dam could be modified to allow sampling of all potential spawners above the dam if necessary, 2) All spring chinook spawners above Tumwater Dam appear to be part of a discrete spawning population or group of populations, 3) The number of spring chinook spawners passing Tumwater Dam is likely to be small enough to make the experiment logistically feasible but large enough to provide adequate statistical power to detect effects. The disadvantages of performing the study on spring chinook above Tumwater Dam include: 1) The presence of several potentially discrete spawning populations above the dam which could confuse interpretation of the experimental results, 2) The very low natural productivity and critical status of mid-Columbia spring chinook salmon may mean that few individuals will return to spawn in some years. Examples of two possible experimental time lines are provided below. Other species/location combinations may also prove to be appropriate and should continue to be explored.

Example 1: Experimental collection time line for a single cohort, two-generation study of adult-to-adult reproductive success. DNA analysis would occur throughout the study. If desired, samples of intermediate life-history stages could be made at various times. Sample sizes in parenthesis are for example only.

Year	Action
1998	<u>Sample parents for generation 1.</u> Collect tissue samples (fin clips) and scale samples for ~100% of the spring chinook passing Tumwater Dam. For each sample record hatchery versus wild status of fish, sex, and any other desired measurements. (n = 800)
1999	
2000	
2001	<u>(optional) Sample three-year-old progeny from generation 1.</u> Collect tissue samples and measurements from a sample of three-year-old spring chinook passing Tumwater Dam. (n = 100)
2002	<u>Sample four-year-old progeny from generation 1 and parents for generation 2.</u> 100% sampling as in 1998. (n = 800)
2003	<u>(optional) Sample five-year-old progeny from generation 1.</u> Collect tissue samples and measurements from a sample of five-year-old spring chinook passing Tumwater Dam. (n = 200)
2004	
2005	<u>(optional) Sample three-year-old progeny from generation 2.</u> Collect samples as in 2001.
2006	<u>Sample four-year-old progeny from generation 2.</u> Collect tissue samples and measurements from a sample of four-year-old spring chinook passing Tumwater Dam. (n = 500)
2007	<u>(optional) Sample five-year-old progeny from generation 2.</u> Collect tissue samples and measurements from large sample of five-year-old spring chinook passing Tumwater Dam. (n = 200)
2008	

Total sample size in example = 2100-2700. Number of years that ~100% of spawners must be sampled = 2.

Example 2: Experimental collection time line for a two-cohort, two-generation study of adult-to-adult reproductive success. DNA analysis would occur throughout the study. If desired, samples of intermediate life-history stages could be made at various times. Samples sizes in parenthesis are for purpose of example.

Year	Action
1998	Sample parents for generation 1 cohort 1. Collect tissue samples (fin clips) and scale samples for ~100% of the spring chinook passing Tumwater Dam. For each sample record hatchery versus wild status of fish, sex, and any other desired measurements. (n = 800)
1999	Sample parents for generation 1 cohort 2. 100% sampling as in 1998. (n = 800)
2000	
2001	(optional) Sample three-year-old progeny from generation 1 cohort 1. Collect tissue samples and measurements from a sample of three-year-old spring chinook passing Tumwater Dam. (n = 100)
2002	Sample four-year-old progeny from generation 1 cohort 1, three-year-old progeny from generation 1 cohort 2, and parents for generation 2 cohort 1. 100% sampling as in 1998 (n = 800).
2003	Sample five-year-old progeny from generation 1 cohort 1, four-year-old progeny from generation 1 cohort 2, and parents for generation 2 cohort 2. 100% sampling as in 1998. (n = 800)
2004	
2005	(optional) Sample three-year-old progeny from generation 2 cohort 1. Collect tissue samples and measurements from a sample of three-year-old spring chinook passing Tumwater Dam. (n = 100)
2006	Sample four-year-old progeny from generation 2 cohort 1 and three-year-old progeny from generation 2 cohort 2. Collect tissue samples and measurements from a sample of three and four-year-old spring chinook passing Tumwater Dam. (n = 500)
2007	Sample five-year-old progeny from generation 2 cohort 1 and four-year-old progeny from generation 2 cohort 2. Collect tissue samples and measurements from a sample of four and five-year-old spring chinook passing Tumwater Dam. (n = 200)
2008	(optional) Sample five-year-old progeny from generation 2 cohort 2. Collect tissue samples and measurements a large sample of five-year-old spring chinook passing Tumwater Dam. (n = 100)

Total sample size in example =3900-4200. Number of years that ~100% of spawners must be sampled = 4.